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Determinants of diet quality and weight status of women participating in the Supplemental Nutrition Assistance Program

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Dedication

This dissertation is dedicated to my son, Vihaan Tejas, and my husband, Prashanth, for their love and support. I also would like to dedicate this dissertation to my parents and my brother.

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Determinants of diet quality and weight status of women participating in the Supplemental Nutrition Assistance Program

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The purpose of this research was to analyze the monthly dietary and food expenditure patterns of women participating in the Supplemental Nutrition Assistance Program (SNAP). The secondary goal was to identify factors that influence weight status of women in SNAP. In Study 1, a 95-item, semi-quantitative food frequency questionnaire based on a 1-week reference period was developed. It was validated against 3-day diet records in a sample of 70 female SNAP participants. The food frequency questionnaire was administered again after one month in a subgroup of 40 women to evaluate its test-retest reliability. Mean daily nutrient intakes obtained from the two tests of the 95-item food frequency questionnaire, and 3-day diet records were calculated. The average correlation and weighted Cohen's kappa for the validity study were 0.60 and 0.39, respectively. The mean correlation and kappa statistics for the reliability study were 0.66 and 0.50, respectively. Thus, the 95-item, 1-week food frequency questionnaire effectively measured diets of women participating in SNAP. In study 2, a sample of 151 SNAP women were administered the 1-week food frequency questionnaire four times, each with an interval of one week, so that it reflected weeks 1, 2, 3 and 4 of the diets of participants. A significant decrease in intakes of fruits, vegetables, whole grains, dairy and total protein foods were observed with an increase in time since receipt of benefits.

Moreover, a decline in diet quality towards the end of the SNAP month was determined. In Study 3, 160 women participating in SNAP saved their grocery receipts for one month, and were measured for height and weight. Spending patterns on 29 food categories were determined from the receipts, and compared to the Thrifty Food Plan (TFP) recommendations. Some of the food categories for which the expenditure was significantly greater than the recommendations included: refined grains, red meat, frozen entrees, soft drinks, and sodas, fruit drinks and ades. A greater amount spent on monthly groceries relative to the TFP recommended total cost was significantly associated with higher compliance of spending on low fat dairy, vegetables, whole grains and fruits to the recommendations. In Study 4, 152 women in SNAP completed the multi-dimensional home environmental scale and adult food security module and were measured for height and weight. Multi-dimensional home environmental subscales that were significantly associated with body mass index, and also differed according to food security status were: availability of unhealthy foods at home and neighborhood safety. Factors measured by this scale significantly mediated the relationship between food insecurity and body mass index.

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Chapter 1: Review of literature

Food insecurity is a major public health problem that affects low-income Americans. It is defined as lack of sufficient access to nutritious food [1]. A number of nutrition assistance programs are administered by the United States Department of Agriculture to combat this problem [2]. These include the Supplemental Nutrition Assistance Program (SNAP), Special Supplemental Nutrition Program for Women, Infants and Children (WIC), National School lunch program, School Breakfast Program, and Child and Adult Care food program. Of these, SNAP (formerly Food Stamps) has emerged as the largest federal food assistance program in the country [3,4]. It was launched in 1964 in order to boost the agricultural economy and improve the nutritional status of low-income households [2]. This program has achieved a vast outreach and served 44 million participants in 2016. Benefits distributed by this program were approximately $67 billion in 2016, and provided an average monthly benefit amount of $125.51 per person [5].

The maximum monthly benefit that can be allotted to SNAP households is based on the Thrifty Food Plan (TFP) [6]. The SNAP allotment is calculated as = maximum monthly benefit for a given household size – 0.3 × net income [7]. The net income is determined by subtracting expenses related to child support, emergency, dependent care, excess shelter, and out-of-pocket medical costs for the elderly and disabled from the gross income. Household benefits are credited once every month to an electronic benefit transfer card given to each SNAP-participating family. These e-cards are used to

purchase food items at authorized retailers, such as supermarkets, pharmacies, and convenience stores.

The food environment in the United States (U.S.) has been transformed, and now offers an abundance of high-fat and high-sugar foods [8]. This change has been accompanied by a shift towards energy-dense diets [9]. Unlike other Federal food assistance programs such as WIC [10] and the National School Lunch and Breakfast Programs [11], the SNAP does not stipulate provision of foods that are aligned to the Dietary Guidelines for Americans. Benefits from this program permit purchase of most foods and beverages, with the exception of alcohol, tobacco, dietary supplements, and hot or prepared foods. However, the lack of restriction for foods limited in desirable nutrients may contribute to unhealthful food choices among SNAP participants. It has been reported that food stamp recipients consume significantly more added sugar and fat than do non-recipients [12]. Thus, nutritional policy changes that address unhealthy eating patterns among SNAP participants are critical for effective use of this program.

An understanding of the dietary behaviors of SNAP participants is required to guide the development of effective policy measures. Many low-income families conduct major shopping trips only once every month, and the majority of food expenditure takes place in the first three days after food stamp benefits are received [13,14]. It has been estimated that 80% of benefits are redeemed within the first two weeks of receipt [15]. Consequently, distribution of benefits once a month may be associated with a trend of adequate household food supply, followed by food shortage at the end of month. As resources decline, families may rely on energy-dense food items due to its perceived cheaper cost

and convenience. Thus, diets of SNAP participants may be sensitive to time since receipt of benefits. It is hypothesized that there may be a decline in diet quality towards the end of month. In order to gain an accurate knowledge of dietary behaviors of SNAP participants, it is vital to investigate food and nutrient intake of this population over the entire month. A period of one month represents an ideal time frame to capture dietary variations of SNAP participants. For this purpose, a food frequency questionnaire (FFQ) based on a reference period of one week will be developed. It will be derived from a previously validated FFQ created by our laboratory [16]. The FFQ is widely used as a dietary assessment tool due to its ability to save cost and time [17,18].

Eating behaviors are governed by a multitude of factors, the complex interaction of which needs to be explored within a population of SNAP participants. Some factors that have been identified to influence food intake include the individual's state of mind [19], environmental settings within the home [20] and community [21], and social and cultural norms [22]. Thus, it is important to utilize a comprehensive approach of the environment while investigating factors that influence health behaviors and outcomes of SNAP participants.

SPECIFIC AIMS

Aim 1: To develop and validate a weekly semi-quantitative, food frequency questionnaire for women participating in the Supplemental Nutrition Assistance Program (SNAP)

Hypothesis: A weekly food frequency questionnaire will be developed and validated to capture monthly variations in food and nutrient intake of individuals participating in SNAP.

Rationale: A validated, 1-week food frequency questionnaire (FFQ) tailored to a population of low-income women does not exist. It is the goal of this research to develop and validate a semi-quantitative FFQ based on a reference period of the previous week. Energy and nutrient intake from 3 days of diet will be compared to those obtained from the FFQ.

Aim 2: To document food expenditure patterns of households participating in the SNAP, and compare it to the Thrifty Food Plan (TFP) recommendations.

Hypothesis: Food expenditure patterns of households participating in SNAP will not meet the TFP recommendations.

Rationale: Knowledge on the type of foods purchased by low-income households is limited. It is the goal of this research to explore purchasing patterns via analysis of grocery receipts.

Aim 3: To explore monthly variations in food and nutrient intake in women participating in SNAP

Hypothesis: Individuals participating in SNAP will experience a period of adequate household food availability followed by a decline during the monthly distribution of benefits, which will diminish diet quality.

Rationale: Many SNAP households depend on one major grocery shopping trip for the month that occurs within the first three days after receipt of monthly benefits. About 80% of benefits are redeemed within the first two weeks of receipt. Subsequently, a drop in household food supply towards the end of the food stamp month will adversely affect diet quality of SNAP participants, as measured by FFQs.

Aim 4: To determine the influence of intrapersonal factors, environmental settings, and social and cultural norms and values on diet quality and weight status of female SNAP participants

Hypothesis: Individual factors, environmental settings, sectors of influence, and social and cultural norms and values, as identified by the Multi-Dimensional Home Environmental Scale (MHES), will mediate the relationship between food insecurity and diet quality, and weight status of SNAP participants.

Rationale: Information is scarce regarding factors that influence diet quality and weight status of SNAP participants. Exploration of factors that influence weight status of SNAP participants will facilitate the development of a comprehensive strategy for healthy eating within the context of obesity prevention.

DIETARY INTAKE OF LOW-INCOME ADULTS BY STATUS OF SNAP PARTICIPATION

Studies regarding the dietary intakes of SNAP participants have shown mixed results. Dietary assessment of low-income adults from the 1999-2008 NHANES demonstrated that only a small proportion of these individuals met the recommendations

for whole grains, fruit, vegetables, fish, and nuts/seeds/legumes. However, some exceeded the recommended amounts for processed meats, sweets and bakery desserts, and sugar-sweetened beverages [23]. Notably, SNAP participants had fewer intakes of whole grains, and higher intakes of potatoes, red meat, and fruit juice when compared to income eligible nonparticipants. Moreover, women SNAP participants had much higher intakes of sugar sweetened beverages, total sugars and sweets-desserts when compared to their counterparts [23].

Diet quality, as measured by the Alternate Healthy Eating Index, was found to be lower among SNAP participants (21.1) when compared to nonparticipants (24.6) [23]. A study that made use of nationally representative data also found that participation in SNAP was associated with lower Healthy Eating Index-2010 diet quality scores (β=-3.18, $p<0.01$). Subgroup analyses showed that lower diet quality was more pronounced among women, Hispanics, and young adults [24]. The relationship between SNAP participation and consumption of sugar sweetened beverages was further substantiated by a second study conducted by Nguyen et al [25]. This analysis indicated that SNAP participation was associated with an increase of 29 calories obtained from sugar-sweetened beverages [25]. The energy intake of sugary drinks remained relatively constant among SNAP participants from 2003-2010 (-10.5%), in contrast to the decline observed in all other groups of nonparticipants (-25.5%) [25]. In contrast, a separate investigation using 1 day dietary intakes from the 2005-2008 NHANES found that SNAP participants were no more likely than nonparticipants to consume sugar-sweetened beverages [26].

Studies that make use of smaller sample sizes have supplemented results obtained from dietary assessment at the national level. Hilmers et al. determined dietary intakes of 661 low-income, Hispanic women in Texas who were enrolled in the SNAP [27]. Although low-income women did not meet the dietary guidelines, those receiving SNAP benefits reported less healthy dietary patterns. These patterns exhibited fewer servings of whole grains (1.12 oz vs 1.76 oz in nonparticipants), but higher intakes of total sugars (82.65 g vs 70.63 g in nonparticipants), sweets and desserts (0.54 servings vs 0.39 servings in nonparticipants), and sugar-sweetened beverages (10.14 oz vs 8.05 oz in nonparticipants) [27]. Sorge et al. conducted a study in Fayette County, Kentucky on 147 SNAP participants [28]. These SNAP participants did not meet the recommendations for fruit and vegetable intake [28]. The proximity to stores that offered few options for healthy food items was associated with a lower probability of consuming at least one serving of fruits (odds ratio = 0.84) and milk (odds ratio = 0.88) per day [28].

WEIGHT STATUS AND SNAP PARTICIPANTS

The relationship between food assistance programs and weight status of individuals has drawn much attention due to the high prevalence of obesity among low-income groups. Cross-sectional studies using CSFII (1994-1996) have indicated an association between participation in this program and an increased body mass index in women (38% higher likelihood of overweight by Townsend et al. [23], 3.6 unit increase in body weight by Chen et al. [24]. However, SNAP did not have a significant effect on overweight/ obesity in men. Dietary data obtained from the National Longitudinal Survey

of Youth (NLSY) also have indicated that women who were currently receiving SNAP benefits had an elevated BMI, and a greater risk of being obese, by as much as 9.1% [25]. The associated risk increased to 20.5% with long-term use of this program [25]. Moreover, SNAP participation for more than 5 years was significantly linked to a simultaneous overweight and obese status in daughters and mothers, respectively [26]. Based on the Panel Study of Income Dynamics (PSID), Jones et al. showed that this program resulted in an average weight gain of 0.8 kilograms per year in food insecure women [27]. Although a vast body of literature has indicated no effect on the weight status in men, a few studies have shown a positive link between SNAP participation and unhealthy BMI in men.

In summary, research has consistently indicated that women, especially those who are long-term SNAP users, have a greater odds of obesity. Some of the factors that have been attributed to this relationship include the monthly cycle of benefit distribution, propensity to purchase energy dense foods, consumption of several meals away from home, psychological stress, and depression [28,29].

MONTHLY BENEFIT DISTRIBUTION AND DIETARY INTAKE OF SNAP PARTICIPANTS

The SNAP benefits are distributed once every month to those who are enrolled in the program. Many low-income families conduct major shopping trips only once every month, and the majority of food expenditure takes place in the first three days after food stamp benefits are received [13]. It has been estimated that 80% of benefits are redeemed within the first two weeks of receipt [15,30]. Research that have examined food insecurity within the month found that households participating in SNAP had a higher likelihood of

reporting food insecurity during the latter third of the month [31]. Moreover, exhaustion of benefits within a short duration has been associated with greater odds of experiencing food insecurity or hunger symptoms by the household [32]. It is expected that the monthly cycle of distribution will have a detrimental impact in the dietary intakes of SNAP participants.

Based on the Consumer Expenditure Survey (1988–92 data) and the Continuing Survey of Food Intake by Individuals (CSFII, 1989–91 data), Wilde et al. showed that SNAP participants who shopped only once every month experienced a drop in their energy intakes by 10% towards the end of the month [13]. Shapiro et al. used dietary data from the CSFII, in combination with the date of receipt of SNAP benefits. It was estimated that a decrease in calorie intake of 0.32-0.40% occurred for every day from the time that benefits were obtained [33].

Hamrick et al. demonstrated that the probability of reporting no eating occurrences in a day was higher for users of the SNAP when compared to nonusers [34]. Moreover, SNAP participants were more likely to report no eating occurrences with an increase in the time since receipt of benefits [34]. In contrast to other investigations that reported a decline in food intake with time from benefit receipt, Kharmats et al. observed higher intakes of energy, fat and protein in the early and later stages of the SNAP cycle in a sample of African Americans [35]. However, dairy intake decreased towards the end of the monthly cycle in this population [35]. These studies provide evidence that food intake varies within the month of SNAP benefits. Thus, a longitudinal design study is vital to understand the week-to-week dietary changes in the monthly SNAP cycle.

FOOD FREQUENCY QUESTIONNAIRES

Food frequency questionnaires (FFQ) have widely been used as a tool for dietary assessment of populations in numerous investigations. Other methods that have been utilized for measurement of diets include dietary records or 24-hour dietary recalls [36]. These require the participant to provide a detailed list of foods consumed in a day, as well as other specifications such as time, location, quantity and type/ brand of food consumed, and use of condiments. Although FFQs may lack the specificity of other dietary instruments, they have been recognized to be less expensive and time-saving, with the ability to capture habitual dietary intake [17,18]. However, each questionnaire needs to be tailored and validated for appropriate use in the target population.

Food frequency questionnaires are commonly based on a reference period ranging from 1 month to 1 year in order to reflect long-term diets. However, FFQs based on a reference period of one week are relatively fewer. To date, 1-week FFQs have been developed and validated in adolescents [37,38], college students [39,40], youth with type I diabetes [41], and adult volunteers [42]. In the present research, we will develop and validate an FFQ to measure weekly diets of low-income women.

FOODS PURCHASED BY SNAP PARTICIPANTS

Allotment of financial resources for purchasing of food differs between households that participate in SNAP, are eligible but do not participate in SNAP, and those with higher incomes. Castner and Mabli found that SNAP households allocated 22% of their expenditures for foods consumed at home; whereas, SNAP-eligible

nonparticipating households spend 18% [43]. Low-income households may adopt several strategies to economize on food purchases, such as buying more discounted items and food products branded by the store, and purchasing less expensive varieties of a product [44]. Cost has been cited to be one of the most important factors related to purchasing of food [44]. An analysis by Frazao et al. showed that a 10% discount in the cost of fruits and vegetables resulted in a 5 to 6% increase in its procurement [45]. Furthermore, coupons for 10% off the original price led to a 2 to 11% escalation in the purchase of these foods [45].

The largest expenditure among food categories in SNAP participants are accounted for by frozen, canned, packaged, and prepared foods, snack foods, condiments and seasonings, sugar and sweets, fats and oils, and nonalcoholic beverages [45]. Meat was one of the highly prioritized food groups, with an estimated expenditure share of 30% [45]. Spending on meat was followed by that for fruit and vegetables, grain and dairy products, respectively. With the exception of eggs, households with an income of ≤130% of the federal poverty level spent significantly less on food categories when compared to those with a higher income [45]. A marginal increase in income, whereby households were still classified as ≤130% of the federal poverty level, resulted in more money being allotted to meat and frozen foods [46]. Taste and convenience could be some of the factors related to the higher precedence given to meat and frozen foods [46].

SOCIO-ECOLOGICAL MODEL

The socio-ecological model posits that health behaviors are governed by an interwoven relationship between individuals and their environment [47]. A multilevel

modeling of features that influence weight status will help to identify risk factors associated with overweight and obesity. Investigations in this area have consistently indicated a connection between household demographics and neighborhood characteristics and obesity [48]. Other dynamics in the socio-ecological framework that may exert an influence on weight status include home and neighborhood environments. These results emphasize the importance of research to focus on a broader spectrum that lies beyond the realm of psychosocial factors. Given that women participating in SNAP have a greater likelihood to be obese [49], it is important to evaluate socio-ecological factors and health outcomes that affect weight status. However, studies that employ the use of this model to identify determinants of weight status in SNAP participants have been limited.

Vedovato et al. focused on the influence of psychosocial factors and excess body weight, and found that body image satisfaction was decreased the odds of overweight or obesity in African American SNAP participants [50]. The perception that healthy foods were convenient also was associated with lower odds of unhealthy weight status [50]. Investigations that have been conducted in a generalized population of low-income adults have indicated the influence of neighborhood environment on weight status. For example, availability of healthy foods in low-income neighborhoods have been inversely associated with the body mass index of its residents [21].

SUMMARY OF INTRODUCTION

The purpose of this research was to assess the monthly variations in the dietary intake of SNAP participants with a validated 95-item, 1-week food frequency

questionnaire. Furthermore, the compliance of food expenditure patterns of households in this program to the TFP recommendations was assessed. A secondary goal was to determine factors that mediate the relationship between food insecurity and diet quality and weight status in women participating in SNAP. The results of this study were intended to provide a greater understanding of dietary intakes and food purchasing patterns of SNAP participants, in order to facilitate the development of effective policy measures that target this program.

Chapter 2: Relative validity and reliability of a one-week, semi-quantitative food frequency questionnaire for women participating in the Supplemental Nutrition Assistance Program

ABSTRACT

The Supplemental Nutrition Assistance Program (SNAP) plays a critical role in reducing food insecurity by distribution of benefits at a monthly interval to participants. Households that receive assistance from SNAP spend at least three-quarters of benefits within the first two weeks of receipt. Since this expenditure pattern may be associated with lower food intake towards the end of the month, it is important to develop a tool that can assess the weekly diets of SNAP participants. The goal of this study was to develop and assess the relative validity and reliability of a semi-quantitative one-week food frequency questionnaire tailored to a population of women participating in the SNAP. The food frequency questionnaire (FFQ) was derived from an existing, 195-item FFQ that was based on a reference period of one-month. This 195-item FFQ has been validated in a population of low-income postpartum women who were recruited from Central Texas in 2004**.** Mean daily servings of each food item in the 195-item FFQ completed by women who took part in the 2004 validation study were calculated to determine the most frequently consumed food items. Emphasis on these items led to the creation of a shorter, one-week FFQ of only 95 items. This new one-week instrument was compared to 3-day diet records to evaluate relative validity in a sample of women participating in the Supplemental Nutrition Assistance Program (SNAP). For reliability,

the FFQ was administered a second time, separated by a one-month time interval. The validity study included 70 female SNAP participants who were recruited from the partner agencies of the Central Texas Food Bank from March-June 2015. A subsample of 40 women participated in the reliability study. Outcome measures were mean nutrient intake values obtained from the two tests of the 95-item FFQ, and 3-day diet records. De-attenuated Pearson's correlation coefficients examined relationships in nutrient intake between the 95-item FFQ and 3-day diet records, and a paired samples t-test determined differences in mean nutrient intake. Weighted Cohen's kappa indicated agreement in quartile classification of study participants by the 95-item FFQ and 3-day diet records, according to nutrient intake. Test-retest reliability was assessed by intraclass correlations and weighted Cohen's kappa. Mean de-attenuated Pearson's correlation between the FFQ and 3-day diet records was 0.61, and the weighted Cohen's kappa, 0.39. Finally, the average test-retest correlation and weighted Cohen's kappa of the FFQ was 0.66 and 0.50, respectively. These results suggest that the one-week, 95-item FFQ demonstrated acceptable relative validity and reliability in low-income women participating in SNAP in Southwestern United States.

INTRODUCTION

Food assistance programs in the United States play a critical role in reducing food insecurity among income eligible participants.[51,52] Of note is the Supplemental Nutrition Assistance Program (SNAP) which provides benefits for individuals with an income ≤ 130% of the Federal Poverty Level, and household assets < $2000.[53,54] The SNAP

benefits are issued once every month and majority of food expenditure takes place in the first three days after program benefits are received.[13,14] In fact, these households redeem over three-quarters of their benefits within the first 2 weeks of receipt.[55] Consequently, food shortages may occur towards the end of the month when benefits are exhausted. Hamrick et al. observed that the odds of reporting no eating occurrences in a day increases towards the end of the month among SNAP participants.[34] Thus, the development of an instrument that effectively measures the weekly diets of SNAP participants is important in nutrition research that targets this population.

Dietary intake assessment methods that are commonly used in population studies include diet records , 24-hour dietary recall, food frequency questionnaires (FFQ) and biomarkers.[36] Food frequency questionnaires have been widely used as dietary assessment tools due to their ability to save cost and time, despite several limitations such as measurement error.[17,18] The choice of a reference period for an FFQ depends on the nature of the study and the population of interest.[39] Traditionally, FFQs are based on a reference period of one month or greater in order to reflect habitual dietary intake of individuals.[56,57] However, the use of FFQs to measure diets over a shorter duration also has been indicated in the literature. To date FFQs based on a reference period of one week have been developed and tested for validity in adolescents,[37,38,58] college students,[39,40] youth with type I diabetes,[41] and adult volunteers.[42] The goal of this research was to develop and assess the relative validity and reliability of a 95-item, semi-quantitative FFQ based on a one-week reference period in a sample of women participating in SNAP.

METHODS

Design

Phase one utilized a secondary dataset comprised of 149 low-income postpartum women recruited from Central Texas in 2004.[59] Participants in the secondary data set had been administered a 195-item FFQ based on a one-month period.[16] This 195-item FFQ was used to develop a shortened, one-week 95-item FFQ by choosing the most frequently consumed items.

In phase two, the newly developed one-week, 95-item FFQ was tested for validity in a multiethnic sample of 70 female SNAP participants recruited from March-June 2015. Participants were recruited via partner agencies of the Central Texas Food Bank and word of mouth. At visit one, participants completed a demographics questionnaire, and were trained in collection of dietary data. Then, they were requested to record their dietary intakes on three alternate days. At visit 2, the 3-day diet records were collected, and participants completed the interviewer-administered, one-week FFQ. The FFQ responses reflected the same week as that of completion of 3-day diet records. The relative validity of the FFQ was assessed by comparison to the 3-day diet records. A sub-sample of 40 women were randomly selected and interview-administered the same 95-item FFQ after one month to assess test-retest reliability. The questionnaires were made available in English and Spanish, and completed using a paper and pencil format.

Sample

Participants for the original 195-item FFQ in Phase one were a convenience sample of tri-ethnic women recruited from a community hospital in Central Texas by personal contact and flyers. The women were aged 18-37 years, 6 months postpartum, eligible for Medicaid (≤185% of the Federal Poverty Level), and did not have any chronic health conditions.[59]

Power analysis was conducted to determine the sample size for Phase two. Correlation coefficients between FFQ and reference instrument usually range between 0.4 and 0.7.[60] In order to be able to detect a correlation coefficient of 0.4 at an alpha level of 0.05 and 95% power, the required sample size was 59. Participants were women who were in SNAP (≤ 130% of the Federal Poverty Level), ages 18-50 years, ability to speak, read and write English or Spanish, and who did not report pregnancy or any serious illness. They were recruited from March to June 2015 at the partner agencies of the Central Texas Food Bank. Eighty-seven women met the eligibility criteria; however, eight women declined participation. Thus, 79 women were enrolled for the study; completed questionnaires were obtained from 72. Energy intakes outside the range of 500-4500 kcal were considered invalid, and two women were excluded due to energy intakes > 4500 kcal, resulting in a final sample of 70 participants for the validation study. The age of the selected sample ranged from 19 to 50 years, and more than half of the participants were Hispanic (Table 3.1). In order to detect a reliability correlation of 0.5[61] at an alpha level of 0.05 and 95% power, the required sample size was 34. A subgroup of

44 women from the final sample was selected randomly for the reliability study, of which 40 women completed the second FFQ.

This study was deemed exempt by the Institutional Review Board for Human Subjects of The University of Texas at Austin. Determination of exempt status was based on 45 46.101 (b)(2) CFR. Participation in the study was voluntary and verbal consent was obtained from participants. The 3-day diet records collected from each participant were sequentially numbered. The FFQs of each participant were given the same numbers as that of the diet records so as to enable comparison of responses between questionnaires.

One-week Food Frequency Questionnaire (FFQ)

The original 195-item FFQ was reported to exhibit good validity and reliability in its population of low-income, postpartum women.[16] First it was revised to develop a food list that incorporated food components more relevant to the new 2015 Dietary Guidelines Advisory Committee Scientific Report.[62] For example, the line item, Rice: white, brown, was split into two: white and brown. This enabled distinction between whole grains and refined grains in the final food list. Then, every line item was reclassified into one of 17 food categories: fruits; fruit juices; dark green vegetables; red and orange vegetables; legumes; starchy vegetables; other vegetables; whole grains; refined grains; meat, poultry, eggs; seafood; nuts, seeds, soy; regular dairy; low fat dairy; fats; sweets; and beverages. Mixed dishes were broken down into individual foods, which were then grouped into one of the food categories. For example, hot dog was disaggregated into two components; refined grains and meat, poultry, eggs. Mean servings of line items in each

food category were calculated to identify the most frequently consumed items in order to finalize the creation of a shortened version consisting of 95 line items. Since the intended purpose of the 95-item FFQ was to measure dietary intake in the past week, the response options of the FFQ were Never or <1 per week, 1 per week, 2 per week, 3 per week, 4 per week, 5 per week, 6 per week, 1 per day and 2+ per day. Portion size options were small, medium, large and extra-large. For example, small, medium, large and extra-large serving size options for beef steak were 2 oz, 4 oz, 6 oz and 8 oz, respectively. Serving sizes for foods were derived from Dietary Guidelines for Americans 2010,[63] MyPlate,[64] and an expert panel consisting of registered dietitians. Participants in SNAP are more likely to have an education level of less than high school when compared to nonparticipants.[65] Thus, the FFQ was interview-administered to this low-literacy population by a graduate student majoring in nutrition.

Three-day Diet Records

Study participants were randomly assigned three alternate days (including one weekend day) for completion of the diet records. Participants were trained to identify portion sizes by the use of food models, photographs, and measuring cups and spoons. Furthermore, they were instructed to provide detailed information pertinent to the foods listed in the diet records, such as fat composition of milk, presence of skin/fat on chicken/meat, mode of food preparation, and use of condiments. The records were reviewed by a nutrition graduate student, and clarified for any unclear information provided on recipes, food description and portion sizes.

Nutrient analysis

FoodWorks 17 software (Long Valley, NJ, 2015)[66] was used to calculate nutrient intakes from 3-day diet records. This program includes nutrient information for 40,000 foods from databases such as the United States Department of Agriculture Standard Reference 27,[67] Food and Nutrient Database for Dietary Studies, [68] and Canadian Nutrient File 2010.[69] No substantial modifications were made to the database. Missing nutrient data for any food were extrapolated from values for closely related foods. Nutrient values for less than 2% of the foods were not found in the database. Thus, the effects of missing information on nutrient estimates were negligible.

One common problem of FFQs is that they contain items with multiple foods. For example, multiple forms of beef were added together in a single line such that it read: Beef: steaks, roasts, brisket, carne asada, barbecue. In order to conduct nutrient analysis of the FFQ, the nutritional value of each line item needs to include nutrient information of all the foods.[70,71] For this purpose, the nutrient content of all individual food items in the FFQ for the four serving size levels (small, medium, large and extra-large) was obtained from the FoodWorks[66] software. Missing responses in the FFQ were imputed as zero. For the entire sample recruited, the total number of items for which there were no responses was 24 out of 6650. Thus, missing data accounted for less than 1% of the total number of possible responses. For line items with multiple foods, the total gram intake of each food for the group, as determined from the 3-day diet records, was divided by the total intake of the aggregated foods to attain the weights. The nutritional value of the line item was calculated by taking the weighted average of the nutrient content of the foods

present in the categorical item. Finally, the nutrient content of every line item for the chosen serving size was multiplied by the corresponding frequency of consumption divided by seven, and summed across all line items. The resulting summations were used to indicate daily nutrient intakes. An alternate method of assuming uniform intake of all foods also was used to determine nutrient content of line items with multiple foods.

Statistical analysis

Descriptive statistics were used to indicate nutrient intake estimated by the FFQ and the reference method. Data were analyzed for normality using skewness and kurtosis. A range of -1 to +1 for skewness and kurtosis was considered acceptable for normality.[72] Nutrient intakes with departures from normality were log-transformed. To assess the relative validity of the 95-item FFQ, Pearson's coefficients were used to determine relationship of nutrient intake between FFQ and mean of 3-day diet records. Determination of actual intake of participants using diet records is subject to intra-individual variability, which in turn, may weaken the correlation coefficients. The Pearson's correlations were de-attenuated to correct for within-person variation[73]; de-attenuated correlations can range from -1 to +1. The formula used was:

De-attenuated Pearson's correlation = Crude Pearson's correlation $\sqrt{(1 + \lambda/n)}$

where λ is the ratio of within- to between-person variance, and n is the number of replicates of dietary data.[73]

Differences in nutrient intakes between FFQ and 3-day diet records were tested for significance by paired sample t-test. The positive or negative deviation of the mean

nutrient intakes estimated by the FFQ with respect to the 3-day food records was used to assess over- or underestimation bias, respectively. The proportion of agreement/disagreement between FFQ and 3-day diet records was determined by classification of participants according to nutrient intake into the same, same or adjacent, opposite and distant quartiles. The extent of agreement in quartile classification of participants was assessed by the weighted Cohen's kappa. This statistic is preferred over its unweighted counterpart when the data are ordinal or ranked.[74] For example, disagreement due to classification of participants in opposite quartile of nutrient intake must be penalized more than that due to participants classified in distant quartiles. The unweighted kappa considers all disagreements to be equal, and therefore, may not be suitable for this analysis.[75] Kappa values were interpreted as: 0.80 nearly perfect agreement, 0.61 - 0.80 good agreement, 0.41–0.60 moderate agreement, 0.21–0.40 fair agreement and, 0.20 poor agreement.[76]

For the test-retest reliability study, nutrient intakes between the two time points were evaluated by the paired sample t-test. Intraclass correlation coefficients were used to demonstrate reliability. A p-value of less than 0.05 was used to test significance of all the analyses. With the exception of weighted Cohen's kappa, all statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS 22, Armonk, NY, 2013).[77] Statistical Analysis Software 9.2 (SAS 9.2, Cary, NC, 2011)[78] was used to determine weighted Cohen's kappa.

RESULTS

Development of the 95-item FFQ

Mean servings of the most frequently consumed line items in the 195-item FFQ are presented in Figure 2.1. The shortened food list consisted of 95 lines items that reflected the most frequently consumed items in each food category. In order of frequency, the five most popularly consumed foods were soda, white bread, whole milk, flour tortillas, and whole grain bread.

Relative validity of the 95-item FFQ

In comparison to 3-day diet records, the FFQ did not significantly differ in the estimates of cholesterol, monounsaturated fat, fiber, vitamin E, zinc and calcium. In contrast to other nutrients, polyunsaturated fat and sodium intakes were underestimated by the FFQ. The average percentage of overestimation of nutrient intake by the FFQ with respect to diet records was 18.5%; whereas, the mean percentage of underestimation was 12.3%. The percentage overestimation of energy intake by the FFQ was 5.6%. De-attenuated Pearson's correlation coefficients for the nutrients measured by the 95-item FFQ and 3-day diet records are presented in Table 2.2. The overall average de-attenuated correlation coefficient between these two measures of diet was 0.61, with a range of 0.39 for manganese to 0.76 for magnesium, indicating acceptable relative validity of the

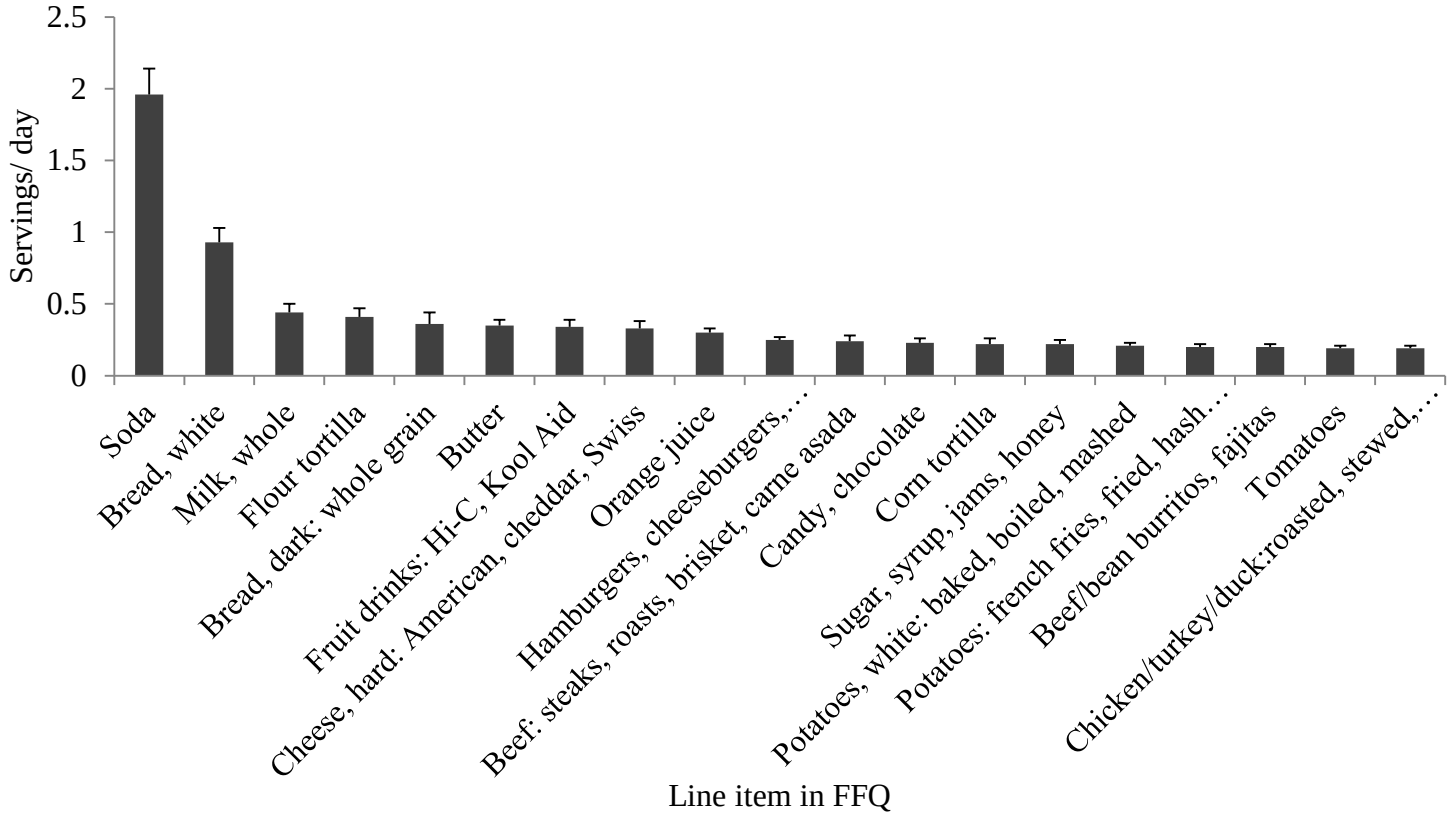


Figure 2.1. Mean daily servings of the most commonly consumed items in low-income postpartum women from Central Texas (n=149), as determined from a 195-item food frequency questionnaire (FFQ)

Table 2.1. Demographic characteristics of a sample of female SNAP[a] participants (n=70)

Demographics	**Data**
Age, years, Mean±SEM[b]	36.8±0.86
Race/ ethnicity, n (%)	
Hispanic	41 (58.6)
Non-Hispanic Black	17 (24.3)
Non-Hispanic White	12 (17.1)
Education level, n (%)	
College graduate	9 (12.9)
Partial college	26 (37.1)
High school	17 (24.3)
Partial high school	12 (17.1)
$\leq 7^{th}$ grade	6 (8.6)

[a]SNAP= Supplemental Nutrition Assistance Program

[b]SEM= Standard Error of Mean

Table 2.2. Comparison of mean daily energy and nutrient intake obtained from 3-day diet records and 95-item FFQ[a], and Pearson's correlation coefficients between intake estimates (n=70)

Nutrient	Diet instrument		Pearson's correlation	
	Diet record	**95-item FFQ**	**Crude**	**De-attenuated**
Energy (kcal)	2394±75.1[b]	2527±75.1[c]	0.70[d]	0.74[d]
Carbohydrate (g)	275±9.1	288±9.7[e]	0.65[d]	0.70[d]
Protein (g)	101.5±3.7	144.7±8.8[c]	0.53[d]	0.57[d]
Saturated fat (g)	33.7±1.4	36.1±1.3[e]	0.58[d]	0.63[d]
Monounsaturated fat (mg)	36.9±1.5	38.2±1.5	0.59[d]	0.64[d]
Polyunstaurated fat (mg)	19.0±0.9	15.3±0.6[c]	0.52[d]	0.57[d]
Cholesterol (mg)	377±23.1	409±18.2	0.43[d]	0.48[d]
Fiber (g)	20.7±0.9	21.6±0.9	0.56[d]	0.62[d]
Vitamin A (μg RAE)	600±57.4	639±27.2[e]	0.49[d]	0.57[d]
Vitamin C (mg)	84±9.1	115±8.7[c]	0.50[d]	0.55[d]
Vitamin D (μg)	3.4±0.3	4.9±0.3[c]	0.54[d]	0.59[d]
Vitamin E (mg)	7.2±0.4	6.6±0.3	0.56[d]	0.61[d]

Table 2.2. Continued

Folate (μg)	520±24.2	604±21.1[c]	0.62[d]	0.68[d]
Niacin (mg)	26.6±1.0	33.5±1.1[c]	0.54[d]	0.59[d]
Thiamin (mg)	1.9±0.1	2.3±0.1[c]	0.62[d]	0.68[d]
Riboflavin (mg)	2.2±0.1	2.4±0.1[c]	0.53[d]	0.57[d]
Iron (mg)	18±0.6	22.4±0.8[c]	0.47[d]	0.50[d]
Zinc (mg)	14.2±0.6	14.7±0.5	0.57[d]	0.61[d]
Calcium (mg)	948±43	979±34.3	0.64[d]	0.68[d]
Sodium (mg)	3998±140.5	3682±131.3[e]	0.50[d]	0.55[d]
Potassium (mg)	2744±104.7	3211±104.6[c]	0.68[d]	0.72[d]
Magnesium (mg)	266±9.6	307±9.7[c]	0.70[d]	0.76[d]
Phosphorus (mg)	1488±51.8	1758±51.6[c]	0.70[d]	0.74[d]
Manganese (mg)	1.7±0.1	2.8±0.1[c]	0.36[d]	0.39 [d]

[a]FFQ= Food frequency questionnaire

[b]Values represented as Mean±Standard Error of Mean

[c] Statistically significant ($P<0.01$) difference in mean intake estimates between the 95-item FFQ and 3-day diet records

[d]Statistically significant correlations ($P<0.01$) between intake estimates obtained from the 95-item FFQ and 3-day diet records

[e] Statistically significant ($P<0.05$) difference in mean intake estimates between the 95-item FFQ and 3-day diet records

instrument. The mean correlation for macro- and micronutrients were 0.62 and 0.61, respectively. The correlation coefficients for all nutrient estimates were significant (p-value <0.01). The mean de-attenuated correlation assuming uniform intake of all foods was 0.61.

Cross-classification of participants into quartiles according to nutrient intakes by 95-item FFQ and 3-day diet records

Table 2.3 illustrates classification of female SNAP participants into quartiles by the 95-item FFQ and 3-day diet records based on nutrient intakes. The percentage of participants who were classified into same, same or adjacent, and distant quartiles by the 95-item FFQ and 3-day diet records for all nutrients averaged 42.4, 83.9, and 13.5%, respectively. The extent of classification of participants into the same or adjacent quartile varied from 72.9% for cholesterol to 94.3% for carbohydrate. Gross misclassification, as defined by classification of participants into opposite quartiles of nutrient intake by the FFQ and 3-day diet records, averaged 2.6%. Percentage of participants who were classified in the first quartile by one of the methods and in the fourth quartile by the other method was lowest for energy, calcium and phosphorus (0%), and highest for niacin, sodium and manganese (5.7%). The weighted Cohen's kappa statistic ranged between 0.24 for manganese and cholesterol to 0.61 for energy, averaging 0.39.

Table 2.3. Agreement in quartile classification of Supplemental Nutrition Assistance Program participating women from Central Texas (n=70) according to energy and nutrient intake obtained from the 95-item FFQ[a] and 3-day diet records

Nutrient	Quartile				Weighted Cohen's kappa (95% CI[c])
	Same (%)	Same or adjacent (%)	Distant[b] (%)	Opposite (%)	
Energy (kcal)	60	91.4	8.6	0	0.61 (0.47-0.74)
Carbohydrate (g)	44.3	94.3	4.3	1.4	0.49 (0.36-0.62)
Protein (g)	40	85.7	11.4	2.9	0.38 (0.22-0.53)
Saturated fat (g)	52.9	88.6	10	1.4	0.51 (0.37-0.66)
Monounsaturated fat (mg)	45.7	88.6	8.6	2.9	0.45 (0.30-0.59)
Polyunstaurated fat (mg)	42.9	81.4	17.1	1.4	0.38 (0.22-0.53)
Cholesterol (mg)	37.1	72.9	22.9	4.3	0.24 (0.06-0.41)
Fiber (g)	37.1	84.3	11.4	4.3	0.33 (0.17-0.49)
Vitamin A (μg RAE)	38.6	80	18.6	1.4	0.33 (0.17-0.49)
Vitamin C (mg)	38.6	77.1	21.4	1.4	0.31 (0.14-0.47)
Vitamin D (μg)	42.9	77.1	20	2.9	0.33 (0.17-0.49)

Table 2.3. Continued

Vitamin E (mg)	31.4	82.9	14.3	2.9	0.28 (0.13-0.44)
Folate (μg)	42.9	84.3	14.3	1.4	0.40 (0.24-0.56)
Niacin (mg)	40	82.9	11.4	5.7	0.33 (0.16-0.50)
Thiamin (mg)	37.1	81.4	15.7	2.9	0.32 (0.17-0.48)
Riboflavin (mg)	35.7	81.4	15.7	2.9	0.31 (0.15-0.46)
Iron (mg)	38.6	80	15.7	4.3	0.31 (0.14-0.48)
Zinc (mg)	42.9	81.4	15.7	2.9	0.37 (0.21-0.53)
Calcium (mg)	51.4	88.6	11.4	0	0.51 (0.37-0.66)
Sodium (mg)	44.3	84.3	10	5.7	0.38 (0.21-0.54)
Potassium (mg)	52.9	88.6	10	1.4	0.51 (0.37-0.66)
Magnesium (mg)	47.1	85.7	12.9	1.4	0.45 (0.29-0.60)
Phosphorus (mg)	45.7	88.6	11.4	0	0.47 (0.33-0.61)
Manganese (mg)	28.6	82.9	11.4	5.7	0.24 (0.08-0.39)

[a]FFQ= Food frequency questionnaire

[b]Distant quartiles are defined as the first and third quartiles, or the second and fourth quartiles

[c]CI=Confidence interval

Test-retest reliability of the 95-item FFQ

Test-retest correlations are shown in Table 2.4. The correlations between times one and two were significant (p-value < 0.01) exhibiting an average of r = 0.66. The mean estimates between the two time points were significantly correlated (p-value<0.01) for all nutrients, with a range of 0.52 for manganese to 0.79 for energy and protein. Mean intakes between the two time points were not significantly different for 15 out of the 24 nutrients. As shown in Table 2.5., classification of participants into quartiles of nutrient intake by the two FFQ administrations averaged at: 50.5% for same quartile, 89.1% for same or adjacent quartile, 8.9% for distant quartiles, and 2.1% for opposite quartiles. The weighted Cohen's kappa ranged from 0.32 for iron to 0.68 for magnesium with an average of 0.50.

DISCUSSION

These results indicate that a one-week, 95-item FFQ was developed successfully from a larger 195-item FFQ. This questionnaire was updated to reflect the latest components recommended by the 2015 Dietary Guidelines Advisory Committee Scientific Report, [25] and demonstrated acceptable relative validity and reliability. In parallel to the results observed in this study, several FFQs have reported both under- and over-estimation of mean intakes of nutrients when compared to the reference method.[39,40,79,80] The percentage bias in estimation of energy intake is comparable to that found by other studies [+5.5% [16], +9.2% [81]]. A study that compared the Block and Willett

Table 2.4. Comparison of mean daily energy and nutrient intake obtained from two 95-item FFQ[a] administrations, one month apart, and test-retest correlations between intake estimates in women participating in Supplemental Nutrition Assistance Program from Central Texas (n=40)

Nutrient	Time point		Intraclass correlation
	1	2	
Energy (kcal)	2496±94.7[b]	2554±91.7	0.79[c]
Carbohydrate (g)	280±11.8	302±11.5	0.63 [c]
Protein (g)	144±9.8	143.9±8.6	0.79 [c]
Saturated fat (g)	35.8±1.7	35.7±1.6	0.63 [c]
Monounsaturated fat (mg)	37.5±1.9	36.5±1.7	0.61 [c]
Polyunstaurated fat (mg)	15.5±0.8	15±0.7	0.70 [c]
Cholesterol (mg)	403±22.7	394±21	0.66 [c]
Fiber (g)	21.5±1.2	27.4±1.3[d]	0.62 [c]
Vitamin A (μg RAE)	629±33.1	674±33.5	0.54 [c]
Vitamin C (mg)	123±11.7	129±7	0.61 [c]
Vitamin D (μg)	4.6±0.3	5.2±0.3	0.60 [c]
Vitamin E (mg)	6.5±0.4	7.4±0.4[d]	0.68 [c]

Table 2.4. Continued

Folate (μg)	586±26	633±29.4	0.61 [c]
Niacin (mg)	33.2±1.4	32.7±1.1	0.71 [c]
Thiamin (mg)	2.2±0.1	2.4±0.1	0.60 [c]
Riboflavin (mg)	2.4±0.1	2.7±0.1[d]	0.56 [c]
Iron (mg)	21.5±0.9	23.1±1[e]	0.63 [c]
Zinc (mg)	14.3±0.7	15.2±0.7	0.68 [c]
Calcium (mg)	983±47.5	1081±50.4[d]	0.71 [c]
Sodium (mg)	3596±163.9	3872±196.2	0.57 [c]
Potassium (mg)	3212±136.9	3690±137.8[d]	0.75 [c]
Magnesium (mg)	309±12.8	356±13.3[d]	0.76 [c]
Phosphorus (mg)	1758±67.7	1927±75[d]	0.77 [c]
Manganese (mg)	2.8±0.2	3.4±0.2[d]	0.52 [c]

[a]FFQ= Food frequency questionnaire

[b]Values are represented as Mean± Standard error of the mean

[c]Statistically significant correlations (P<0.01) between intake estimates obtained from the two 95-item FFQ tests

[d]Statistically significant (P<0.01) difference in mean intake estimates between the two 95-item FFQ tests

[e]Statistically significant (P<0.05) difference in mean intake estimates between the two 95-item FFQ tests

Table 2.5. Agreement in quartile classification of Supplemental Nutrition Assistance Program participating women from Central Texas (n=40) according to energy and nutrient intake by 95-item FFQ[a] administered twice, one month apart

	Quartile				
Nutrient	**Same (%)**	**Same or adjacent (%)**	**Distant[b] (%)**	**Opposite (%)**	**Weighted Cohen's Kappa (95% CI[c])**
Energy (kcal)	60	90	10	0	0.60 (0.42-0.78)
Carbohydrate (g)	40	87.5	10	2.5	0.40 (0.20-0.60)
Protein (g)	62.5	92.5	7.5	0	0.64 (0.47-0.81)
Saturated fat (g)	45	90	10	0	0.48 (0.30-0.66)
Monounsaturated fat (g)	50	82.5	15	2.5	0.44 (0.23-0.65)
Polyunsaturated fat (g)	50	90	10	0	0.52 (0.34-0.70)
Cholesterol (mg)	42.5	85	12.5	2.5	0.40 (0.19-0.61)
Fiber (g)	62.5	92.5	7.5	0	0.64 (0.47-0.81)
Vitamin A (μg RAE)	42.5	87.5	7.5	5	0.40 (0.20-0.60)
Vitamin C (mg)	42.5	90	2.5	7.5	0.40 (0.20-0.60)
Vitamin D (μg)	45	82.5	15	2.5	0.40 (0.19-0.61)

Table 2.5. Continued

Vitamin E (mg)	42.5	87.5	7.5	5	0.40 (0.20-0.60)
Folate (μg)	42.5	92.5	7.5	0	0.48 (0.31-0.65)
Niacin (mg)	50	87.5	10	2.5	0.48 (0.28-0.68)
Thiamin (mg)	50	90	5	5	0.48 (0.28-0.68)
Riboflavin (mg)	42.5	92.5	7.5	0	0.48 (0.30-0.66)
Iron (mg)	45	75	20	5	0.32 (0.09-0.55)
Zinc (mg)	52.5	87.5	7.5	5	0.48 (0.27-0.69)
Calcium (mg)	65	92.5	5	2.5	0.64 (0.46-0.82)
Sodium (mg)	52.5	85	12.5	2.5	0.48 (0.27-0.69)
Potassium (mg)	57.5	97.5	2.5	0	0.64 (0.49-0.79)
Magnesium (mg)	67.5	92.5	7.5	0	0.68 (0.52-0.84)
Phosphorus (mg)	52.5	97.5	2.5	0	0.60 (0.44-0.76)
Manganese (mg)	50	90	10	0	0.52 (0.34-0.70)

[a]FFQ= Food frequency questionnaire

[b]Distant quartiles are defined as the first and third quartiles, or the second and fourth quartiles

[c]CI=Confidence Interval

one-week FFQ to 6-day diet records showed percent underestimation of energy intakes by 6.6% and 7.7%, respectively.[40] Comparison of another one-week FFQ to mean of 3-day recalls showed a bias of -18.6% in the estimation of energy intake by the FFQ.[39] However, Jones et al. have shown that energy intake estimated by a one-month FFQ differed by +25.8% of the 3-day diet records.[82] An explanation for closer relationships of energy intake observed in this study may be the relatively short reference period used for the FFQ. This process could have helped to minimize incomplete data, and provided energy estimates that were comparable to 3-day diet records.

Correlation coefficients between FFQs and the reference instrument have been observed to be in the range of 0.4-0.7 for the majority of validity studies.[60] The average validity correlation found in this study is quite similar to that reported by Eck et al. [39] for a one-week FFQ (0.59), and higher than that of other one-week FFQs including the Block Kids Questionnaire (0.45),[37] FFQ for youth with type 1 diabetes (0.38),[41] and New Zealand Adolescent FFQ (0.38).[38] In contrast, it is slightly lower than the average values for the Block (0.65),[40] and Willett one-week FFQ (0.69),[40] but these FFQs were not validated in a population of low-income women. The average validity correlation of the 95-item, one-week FFQ (0.61) was higher than that by Nath et al. (0.42) who also utilized 3-day diet records as the reference method. But their FFQ used a much longer reference period of 1 year.[83]

For FFQ studies that included low-income women in the overall sample, the mean correlation in this study is higher than average values observed by Kristal et al. (0.40),[84] Yanek et al. (0.45),[85] Wei et al. (0.47),[86] and Baer et al. (0.48, 0.47).[87] It also is higher

than that found for the FFQ used in the Iowa Women's Health Study (0.37).[88] However, it is lower than the average reported for the Spanish language questionnaire used in the Study of Women's Health Across the Nation (0.64).[80] The mean correlation for micronutrients for the 95-item FFQ (0.61) is greater than the value reported by the Women's Health Initiative FFQ (0.53), but comparable for macronutrients (0.62 vs 0.61).[79] Discrepancies in the reported correlation coefficients among investigations may be due to differences in the number of items of the FFQ, the reference method used for comparison, the demographics of the population under study, and the nutrients chosen for analysis. Other FFQs have not been validated to evaluate diets of low-income women using a reference period of 1 week.

The mean percentage of exact agreement in quartile classification (42.4%) is comparable to the average proportions obtained by Shu et al. (40.3%)[89] and Marks et al. (40.4%),[90] and is slightly lower than that observed by Eck et al. (46.5%).[39] With the exception of three nutrients, participants who were grossly misclassified were found to be <5%. The weighted Cohen's kappa statistic indicates good agreement for energy intake, and fair to moderate agreement for all of the nutrients measured. The mean weighted kappa in this study (0.39) is similar to that found by Tokudome et al. (0.39)[91] and Selem et al. (0.37)[92], and slightly greater than that obtained by Hebden et al. (0.35)[93] and Zhuang et al. (0.34).[94] This value also is higher than the average weighted kappa found by the Nutrition, Environment, and Cardiovascular Health study that validated the FFQ against biomarkers.[95] Thus, the weighted kappa in this study indicates an acceptable level

of conformity between the 95-item FFQ and 3-day diet records in quartile classification of participants based on nutrient intake.

The conventional time gap to test the reproducibility over time of a FFQ ranges from 1 month to 1 year.[96] A one-month interval was chosen since it was not considered to be long enough for considerable changes in dietary habits, while also ensuring that participants do not recall their responses from the first FFQ administration. The reproducibility study yielded a mean correlation coefficient of 0.66 between the first and second FFQ tests. This test-retest correlation is strong, and is higher than the average values reported by other studies, including Khani et al. (0.61),[97] Selem et al. (0.53),[92] and Shu et al. (0.51).[89] The average correlation of the current instrument is comparable to that obtained by Erkkola et al. (0.65).[98] The mean weighted Cohen's kappa for the reproducibility study is similar to that observed by Selem et al (0.50).[92] In sum, the new 95-item instrument exhibited good temporal stability in the population of SNAP participants.

A drawback is that the sample recruited for this study was predominantly Hispanic, thereby limiting the generalizability of this instrument for use in the larger SNAP population. The reference method used for comparison of the 95-item FFQ was a dietary record completed on three alternate days. Although other self-reports of dietary measures are used for FFQ validation,[99] these also are prone to systematic bias that could be correlated to the FFQ.[100,101] This limits the validity of the food record as a reference instrument. The utilization of biomarkers, in the place of self-reports of dietary measures, would have been preferable, but this method was outside the scope of this study.

Completion of food records on nonconsecutive days was chosen to provide a greater variety of the participants' diet over a week, by avoiding documentation of leftover consumption on a subsequent day. It is plausible that administration of the FFQ after 3-day food records could have improved participants' FFQ responses due to better recall of their diets. When population-specific dietary intake can be obtained, the optimal method to handle line items with multiple foods is to use the weighted average of the nutrient content of the foods.[70,102] However, for line items with multiple foods, the use of a weighted mean of foods may provide unrealistic nutrient estimates, especially in cases where the study participant consumed only one of the foods present in the line. Furthermore, the use of 3-day diet records to determine weights of each food could bias the validity of the FFQ. An alternate technique of assuming uniform intake of all foods yielded the same mean correlation (0.61) as that of the first method. The average weighted Cohen's kappa was similar (0.39 for original and 0.38 for alternate method).

The conventional purpose of FFQs is to indicate long-term diets of individuals.[36] The newly developed FFQ covers a short duration, so it is limited for determination of dietary patterns. Yet, the reference period is well-suited for the purpose of this research, assessment of weekly diets of SNAP participants within a monthly cycle of benefit distribution. The use of 7-day diet records to measure weekly diets of SNAP participants may be preferred in the place of FFQ. However, this method was not chosen due to participant burden, and associated attrition rates. Finally, FFQs with a greater number of line items have been shown to demonstrate greater validity than questionnaires with fewer items.[99] But long FFQs have heavy participant burden, and may not be suitable for

all types of research. The number of items in food frequency questionnaires in the literature has varied between five and 350.[99] Shorter questionnaires have commonly been used to assess intakes of single nutrients.[99] The newly developed FFQ contains 95 items, which is slightly higher than the average number of items (N=88) reported by Cade et al.[99] A length of 100 or more food items is considered desirable for an FFQ to be able to comprehensively assess nutrient intakes of a population.[60] Although the 95-item FFQ is intended to measure overall diets of SNAP participants, the use of one-week reference period is expected to overcome the limitations of a smaller questionnaire. Furthermore, the FFQ was evaluated for a wide range of micronutrients, including the essential trace elements, due to their importance in human nutrition and metabolism.[103,104] Future research could focus on evaluating the performance of the 95-item FFQ against a validated, widely used FFQ.

CONCLUSIONS

The present study suggests that the 95-item FFQ has acceptable relative validity and reliability for determination of dietary intake of female SNAP participants in Southwestern United States.

Chapter 3: Compliance of food expenditure patterns to recommendations among households participating in the Supplemental Nutrition Assistance Program

ABSTRACT

The Supplemental Nutrition Assistance Program (SNAP) increases the food purchasing power of its clients by distribution of monthly benefits. The goal of this study was to determine compliance of food purchasing patterns of SNAP participants to recommendations. A total of 160 women receiving SNAP benefits participated in the study. They were instructed to save grocery receipts for one month. At visit 2, grocery receipts were collected, a demographics questionnaire was administered, and participants were measured for height and weight. Foods listed on the grocery receipts were divided into 29 categories. The household percentage expenditure on each food category was calculated and compared to the Thrifty Food Plan (TFP) 2015 recommendation. A sign test with a Bonferroni-Holm correction was utilized to determine differences between actual and recommended expenditures for 29 food categories. Regression analyses was conducted to determine the relationship between compliance of the monthly grocery expenditure to the TFP recommended total cost and amount spent on 29 food categories. Food categories that were significantly greater than the TFP recommendations included refined grains; red meat; frozen entrees; and soft drinks, fruits drinks and ades. Those that were significantly lower were dark green vegetables, whole grain breads, rice and pasta,

orange vegetables, and ready-to-serve and condensed soups. A greater amount spent on monthly groceries relative to the TFP recommended total cost was significantly associated with higher compliance of spending on low fat dairy, vegetables, whole grains and fruits to the recommendations. Food purchasing choices of this sample of SNAP participants did not meet TFP recommendations. Thus, it is vital to provide nutrition education to SNAP participants so that they can achieve a low-cost, healthy diet. Furthermore, monthly grocery expenditures lower than the TFP recommended total cost adversely affected the amounts spent on low fat dairy, whole grains, fruits and vegetables. Future research could focus on psychosocial factors associated with inadequate grocery spending among SNAP participants.

INTRODUCTION

Food insecurity is a public health problem among low-income populations in the United States (U.S.) [105,106]. A number of nutrition assistance programs have been created to combat this problem [2]. Of these, the Supplemental Nutrition Assistance Program (SNAP) (previously Food Stamps) is the largest in the U.S [3,4]. It aims to strengthen food purchasing power by distribution of monthly benefits [107]. These benefits enable an individual to buy most foods and beverages, with the exception of alcohol, tobacco, dietary supplements, and hot or prepared foods [108]. In 2015, nearly $69.7 billion was distributed as SNAP benefits to 45.8 million individuals [109]. The best possible and most effective use of these benefits is essential, so that SNAP participants can achieve low-cost, healthy diets.

Food purchasing behavior is an important determinant of diets in low-income population, as 72% of the energy intake is accounted for by foods consumed at-home [20]. Household food inventories [110-116], scanner data [117-120] and grocery receipts [121-128] are methods used to assess food expenditures of households. Of these, grocery receipts are considered to provide a detailed representation of household food purchases over a multi-week time period [129]. The combination of receipt data with household characteristics identifies families that may be at the highest risk for making choices of lower quality foods [123]. In a sample of 50 families, DeWalt et al. found that spending patterns across food categories were related to the number of meals eaten away from home [125]. Other studies that utilized grocery receipt data reported that spending patterns were associated with ethnicity [126], income [127], and perceived body size [128]. Food expenses obtained from other sources, such as the Family Food Expenditure Survey, also have been related to educational level [130], household composition [130] and income [130,131].

Food plans developed by the United States Department of Agriculture's (USDA) suggest recommended amounts to be spent on groceries in order to help families achieve a nutritious diet [6]. These include the thrifty-, low-cost, moderate-cost and liberal-cost plans. This paper focuses on the thrifty food plan (TFP) which provides guidance on food spending for households that are at or below 130% of the Federal Poverty Level. The objective of this study was to discern monthly food expenditure patterns of SNAP clients by analysis of grocery receipts, and to compare these to the TFP recommendations. Although the TFP offers low-cost food choices, SNAP households may not spend the recommended amount for total groceries [46]. Subsequently, this disparity may affect the

purchasing patterns of certain food categories. A secondary goal of this study was to determine the influence of the amount spent on total groceries on expenditure patterns of food groups.

METHODS

Design

A sample of 160 women successfully completed the study. On the first encounter, women were instructed to save household grocery receipts for one month. At a second visit, receipts for the 1-month period were collected, and participants were administered a demographics questionnaire and measured for height and weight.

Participants

Enrollment criteria were: participation in the SNAP program, ages 18-50 years old, and Hispanic, non-Hispanic White or African-American ethnicity. Since women were the primary grocery shoppers in this population, male SNAP participants were not recruited. Pregnant or lactating women and women with any serious illness were excluded. A total of 217 women who met the criteria were recruited from low-income residential housing and neighborhood centers in Central Texas from January-December 2015. Of the 217 women recruited, 166 completed the study. Six participants were excluded due to insufficient grocery receipt data; thereby resulting in a final sample of 160. This study was granted an exempt status by the Institutional Review Board at The University of Texas at Austin, based on 45 46.101 (b)(2) Code of Federal Regulations.

Participation in the study was voluntary and informed consent was obtained from participants. The receipts and demographics questionnaire were numbered sequentially.

Demographic Questionnaire

A modified demographics questionnaire, developed by the author [132], was used to record information regarding ethnicity, age, education, amount of monthly SNAP benefits, income, household size, and age of each household member.

Anthropometrics

Height was measured with a stadiometer (Health O Meter, McCook, Illinois) and weight was determined using a digital weighing scale (Health O Meter, McCook, Illinois). Weight (kilograms) / height (meters) ^{2} was used to calculate BMI.

Thrifty Food Plan (TFP) 2015

The TFP is the basis of the amount of SNAP benefits that are needed to achieve a healthy diet at a minimal cost[32]. The cost of the TFP is based primarily on raw ingredients over convenience foods, and assumes that all meals are prepared at home. The 2015 plan provides the percentage expenditure that should be spent on 29 food categories for 15 age-gender groups. The TFP recommendation for each food category was determined from a weighted average of the amount to be spent on the food category for each of the age-gender classifications, in which average was weighted according to the number of household members in each age-gender cohort. The total monthly

recommended cost for groceries also was calculated by summation of the indicated costs on 29 food categories (Personal Communication, Lino M).

Food Receipts

Participants were asked to collect all grocery receipts for one month, as SNAP clients receive their program benefits once a month. Moreover, distribution of benefits once every month has been associated to a trend of decreased grocery expenditures towards the end of the month [32,133,134]. Thus, a 1-month time period would be inclusive of these changes in expenditures. The amounts related to SNAP benefits for one month were recorded from the receipts, and compared to the benefit amount specified in the demographic questionnaire. If the total expenditure obtained from the receipts was less than 90% of the benefit amount denoted in the demographics questionnaire, the receipts of the respective participant were excluded from analysis. By this criterion six participants were excluded, decreasing the sample size to 160. A cut-off of 90% of the total amount of benefits received from SNAP, as indicated in the demographics survey, was utilized since program benefits are sometimes carried over to the next month. Consequently, some individuals may not spend their entire benefits within one month. By this method, the average SNAP-related expenditure for the sample of 160 women was 100.5% of the monthly benefit amount specified in the demographics.

Each food item in the receipts was classified into one of the 29 TFP food categories. The amount and percentage amount spent on each food category was determined. Food items with indistinct description on receipts were clarified by

consulting with the listed retailer. Four TFP food categories were expanded for a more detailed analysis of expenditure patterns, including 1) refined grains; 2) whole milk, yogurt and cream; 3) potato and potato products; and 4) soft drinks, sodas, fruit drinks and ades. For example, refined grains was divided further into refined grains bread, rice and pasta; sweet snacks; salty snacks; and cereals.

Statistical Analysis

Descriptive statistics were used for all demographic characteristics. A sign test with a Bonferroni-Holm correction was conducted to determine differences between actual household food expenditures and recommendations for the 29 TFP food categories. This method was chosen over the traditional Bonferroni correction, in order to retain greater statistical power [135]. A simple linear regression was used to determine the association between demographic variables, such as household size, number of children and socio-economic status indicator, and compliance of total grocery expenditure to TFP recommended cost. Univariate linear regression analyses were conducted using the difference between the total grocery expenditure and TFP recommended cost as the independent variable. The difference between the amount spent on each food category and its respective TFP recommendation was used as the dependent variable. The standardized β coefficient, and adjusted R^2 are reported, with $p<0.05$ used for significance. All the analyses were performed using the Statistical Package for the Social Sciences (SPSS 22, Armonk, NY, 2013) [77].

RESULTS

Demographics

The age of participants ranged from 19-50 years, and the median household size was three. The household income was adjusted for family size by dividing it by the Census Bureau-based poverty threshold, as described by Duncan et al., in order to obtain an optimal socioeconomic status indicator [136]. The mean value of this indicator was 0.68. The proportion of participants who were classified as overweight/obese (BMI≥25 kg/m^2) was 71.3%. The overwhelming majority of the total sample was Hispanic (72%). About 38% of the participants had a partial college degree, and 62% had an educational level less than partial college.

Food purchasing patterns and TFP recommendations

Figure 3.1 shows a comparison of recommendations of the TFP for 29 food categories with monthly percentage food expenditures of SNAP households. Significant differences between actual expenditure and TFP recommendation were found for numerous food categories, with the exception of other vegetables, gravies and condiments, fats, and coffee and tea. Food categories and the percentage by which the actual expenditures exceeded recommendations were: refined grains (48.3%); red meat (46.6%); frozen entrees (98.9%); soft drinks, fruits drinks and ades (99.0%); bacon, sausage and lunch meats (94.7%); sugar, sweets and candies (97.3%); cheese (87.9%); milk drinks and desserts (98.2%); whole milk, yogurt and cream (58.1%); eggs (70.2%);

Table 3.1. Demographic profile of a sample of women participating in SNAP[a] (n=160)

Demographics	**%**
Age, yrs	
19-30	26.1
30-40	55.4
40-50	18.5
Household size	
< 2	10.0
2-4	67.5
> 4	22.5
Number of children	
< 2	39.4
2-4	60.0
> 4	0.6
Socio-economic status indicator	
< 0.60	33.1
0.60-1.00	47.8
1.00- 1.27	19.1
Body mass index, kg/m^2	
≤ 24.9	28.7
25-29.9	35.0
≥ 30	36.3
Race/ ethnicity	
Non-Hispanic White	10.0
Non-Hispanic Black	18.8
Hispanic	71.3

Table 3.1. Continued

Education	
≤ Partial high school	29.6
High school	32.7
Partial college/ graduate	37.7

[a]SNAP = Supplemental Nutrition Assistance Program

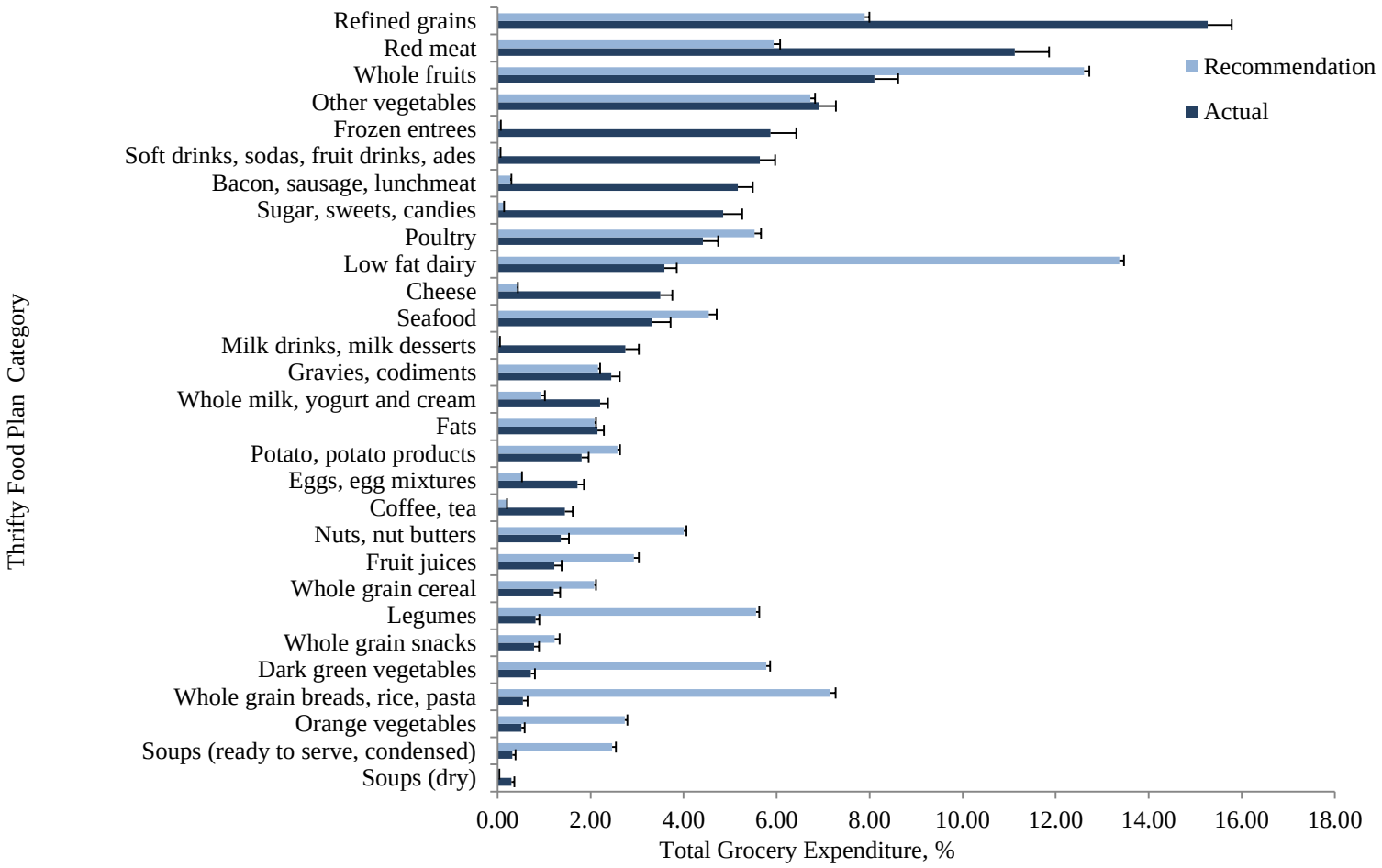
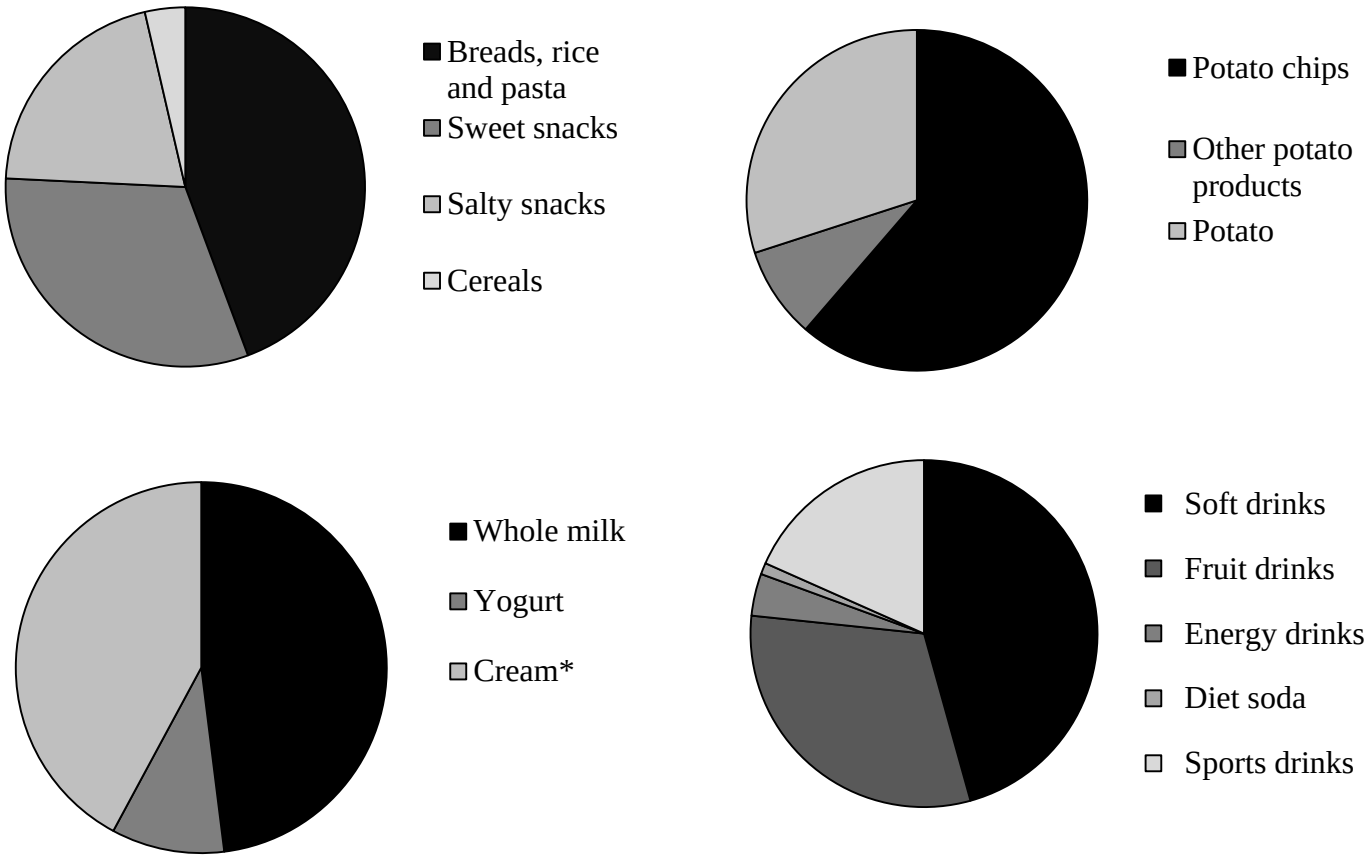


Figure 3.1. Comparison of monthly percentage food expenditures of Supplemental Nutrition Assistance Program participants (n=160) with the recommendations of the Thrifty Food Plan (TFP) for 29 food categories

and dry soups (87.9%). Categories in which the expenditures were significantly lower than recommendations were whole grain breads, rice and pasta (92.4%); whole grain cereals (41.8%); potatoes and potato products (29.9%); dark green vegetables (87.7%); orange vegetables (81.2%); whole grain snacks (36.2%); legumes (85.4%); whole fruits (35.8%); fruit juices (58.4%); low fat dairy (73.2%); seafood (26.7%); poultry (20.1%); nuts and nut butters (66.2%); and ready-to-serve and condensed soups (87.2%). Food categories for which the percent expenditure did not significantly differ from recommendations were: other vegetables, gravies and condiments, fats, and coffee and tea. Refined grains, red meat, whole fruits and other vegetables represented the highest proportions of expenditure; whereas, food categories with the lowest percentage expenditures were soups (ready-to-serve and condensed), soups (dry), orange vegetables, and whole grain grain breads, rice and pasta. The monthly amount of purchase was highest for refined grains ($45.53), followed by red meat ($32.35).

Figure 3.2. illustrates that bread, rice, and pasta and sweet snacks collectively were 75% of the total expenditure within refined grains. A breakdown of potato and potato products showed that expenditure on potato chips and products ($3.81) was more than three times that of potatoes ($1.58). Whole milk ($3.31) and cream ($2.91), such as sour cream, cream substitutes and dips accounted for a greater share than full fat yogurt ($0.68). Finally, the purchase amount of soft drinks ($8.14) was the highest within the soft drinks, fruit drinks, and ades category.



*Includes fluid creams, cream substitutes and dips

Figure 3.2. Percentage amount spent on sub groups within the food categories of the Thrifty Food Plan

Adherence of monthly grocery expenditure to TFP recommended cost

Table 3.2 indicates the average monthly grocery expenditure, the monthly TFP recommended total cost, and the amount of spending accounted by SNAP benefits. The monthly grocery expenditure and SNAP benefits utilized were lower than the mean TFP recommended total cost calculated for the participating households ($476) ($p<0.001$). Household size ($\beta= -0.789$, $p<0.001$) and number of children ($\beta= -0.635$, $p<0.001$) were negatively associated with compliance of monthly grocery expenditure to the TFP recommended total cost; no significant relationship was observed for household size-adjusted family income.

Table 3.3 shows the relationship between total grocery expenditure and food category spending relative to Thrifty Food Plan recommendations among Supplemental Nutrition Assistance Program participants using univariate regression analyses. A greater amount spent on monthly groceries relative to the TFP cost was significantly associated with an increased adherence to recommendations for majority (20 of the 29) of the food categories. Moreover, a standardized β coefficient of greater than 0.6 was observed for low fat dairy, legumes, dark green vegetables, whole grain breads, rice and pasta, orange vegetables, fruits, other vegetables, and potato and potato products. The amount spent on monthly groceries did not significantly influence the compliance of the following food categories to TFP recommendations: cheese, frozen entrees, sugars, sweets and candies, milk drinks and milk desserts, soups (dry), bacon, sausage and lunchmeat, soft drinks, sodas, fruit drinks and ades, whole milk, yogurt and cream, and coffee and tea.

Table 3.2. Average recommended and actual grocery expenditure for a sample of households participating in SNAP[a]

Grocery Expenditure Per Month	**Dollars**
Thrifty Food Plan recommendation	476±15.06[b]
Actual grocery expenditure	309±8.53
Difference between Thrifty Food Plan recommendation and actual grocery expenditure	167±12.73*
SNAP benefits utilized	243±8.75
Difference between Thrifty Food Plan recommended expenditures and SNAP benefits utilized	233±13.11*

[a]Mean±Standard Error of Mean

[b]SNAP = Supplemental Nutrition Assistance Program

*$p<0.001$

Table 3.3. Relationship between total grocery spending and food category expenditure, relative to TFP recommendations[a]

Food category	**Adjusted R^{2b}**	**Standardized β coefficient [c]**	**p-value of β**
Low fat dairy	0.694	0.834	0.000
Legumes	0.672	0.821	0.000
Dark green vegetables	0.584	0.766	0.000
Whole grain breads, rice and pasta	0.569	0.756	0.000
Orange vegetables	0.483	0.697	0.000
Fruits	0.475	0.692	0.000
Other vegetables[d]	0.399	0.634	0.000
Potato and potato products	0.393	0.630	0.000
Nuts and nut butters	0.307	0.558	0.000
Fruit juice	0.255	0.510	0.000
Gravies and condiments	0.209	0.462	0.000
Soups (ready to serve and condensed)	0.207	0.461	0.000
Fats	0.202	0.454	0.000
Poultry	0.152	0.396	0.000
Refined grains	0.150	0.394	0.000
Whole grain cereal	0.122	0.357	0.000
Whole grain snacks	0.110	0.341	0.000
Eggs and egg mixtures	0.086	0.302	0.000
Seafood	0.083	0.298	0.000
Red meat	0.066	0.267	0.001
Cheese	0.010	0.126	0.112
Frozen entrees	0.009	0.122	0.123

Table 3.3. Continued

Sugar, sweets and candies	0.007	0.116	0.145
Milk drinks and milk desserts	0.006	0.112	0.158
Soups (dry)	0	0.078	0.327
Bacon, sausage and lunchmeat	-0.002	0.069	0.386
Soft drinks, sodas, fruit drinks and ades	-0.003	-0.053	0.502
Whole milk, yogurt and cream	-0.006	-0.015	0.848
Coffee and tea	-0.006	0.004	0.958

TFP = Thrifty Food Plan

[a]Regression models used difference between total grocery expenditures and TFP recommended total cost as the independent variable, and difference between amount spent on each food category and TFP recommendation for that food category as the dependent variable

[b]Proportion of variation in food category spending that is explained by total grocery expenditure, relative to TFP recommendations

[c]Change in standard deviation of food category spending for a standard deviation increase in the total grocery expenditure, relative to the TFP recommendations

[d]Vegetables other than potato, legumes, dark green and orange vegetables

DISCUSSION

These results show that food spending patterns of SNAP participants did not meet the majority of the recommendations of the TFP. Thus, this population did not make the best possible food choices, and may consume diets that lack optimal nutritional quality. Of particular concern is that soft drinks, sodas, fruit drinks and ades represented 5.7% of the total market basket expenditure. The amount spent on this category is similar to that obtained by Andreyeva et al. who utilized grocery scanner data from a supermarket chain to assess beverage purchases of households [137]. Expenditures comparable to ours were observed for soft drinks (2.6% vs 2.7%), fruit drinks (1.4% vs 1.5%) and energy drinks (0.3% vs 0.2%) [137], respectively. However, their reported spending was slightly lower for 100% fruit juices (1.2% vs 2.2%) and diet beverages (0.07% vs 0.9%), but higher for sports drinks (0.9% vs 0.4%), respectively. Moreover, spending on soft drinks, sodas, fruit drinks and ades was comparable to that reported by Garasky et al. using point-of-sale transaction data from 2011 [138].

The total of refined grains and red meat combined represented one-quarter of the monthly household expenditure share on grocery purchases. The percentage expenditure on these two food categories were double the TFP recommendations. It is noteworthy that the percentage amount spent on the food category, other vegetables, was similar to that of the TFP recommendation. This congruence might be attributed to the high percentage of a Hispanic population in our sample, as the amount spent on vegetables is greater among Hispanics when compared to Non-Hispanic Whites and African Americans [126].

The mean SNAP benefits ($243) in our study represented 79% of total household grocery expenditure, indicating these benefits are a critical resource for food supply in this low-income population. The monthly benefit amount and total grocery expenditure were lower than the TFP recommended total cost by approximately 49% and 35%, respectively. Moreover, total grocery expenditures lower than the TFP recommended total cost were reported for 84% of the households. However, the TFP assumes that SNAP clients prepare all their meals from scratch using raw ingredients. In contrast, the average meal preparation time in the US has been shown to be less than that indicated by the TFP model [139]. Thus, families with lower grocery expenditures could be relying on food away from home due to lack of time or other resources. The share of groceries accounted by frozen entrees (5.9%) in the present study suggests a limited use of convenience foods in this population. This study also found that the number of children negatively affected the compliance of monthly grocery spending to the TFP recommended total cost. The presence of children could influence eating patterns of the household, such as greater consumption of food away from home, thereby explaining the observed lower grocery expenditure.

A higher expenditure for total monthly groceries was associated with greater adherence to the recommended spending for several nutrient-dense food groups, including low fat dairy, vegetables, whole grain breads and fruits. But, the average amounts spent on these food groups did not meet the TFP recommendations. The limited purchasing of these nutrient-dense food categories in SNAP households should be

addressed in nutrition education efforts, especially in families that spend substantially lower than recommended amounts for total monthly groceries.

Snacks that are high in sugar and fat accounted for about 52% of the refined grain-based purchases. Thus, it would be helpful for the TFP to define sub-groups within the refined grains category, and provide recommended expenditures for these groups. Finally, adherence of the monthly grocery expenditure to the TFP recommended total cost did not change the amount spent on some food groups that were greater than the recommendations, including frozen entrees, sugar, sweets and candies, bacon, sausage and lunchmeat, and soft drinks, fruit drinks, sodas and ades. Thus, it is important for interventions to focus on achieving moderation of these food categories among SNAP families.

The use of grocery receipts has an advantage as an unbiased indicator of nutrition behavior since it excludes errors that may occur with self-report. However, a limitation is that the type of foods purchased may vary widely from one shopping trip to another, and receipt data from a single shopping occasion may not represent consistent food purchasing behaviors of an individual. Thus, collection of grocery receipts for one month as done in this study reduces bias that could arise from a one-time assessment of food purchasing patterns. The matching of benefits received versus the total benefit amount on the receipts validates the completeness of the receipts for the 1-month time period. Similar validation criterion could not be adopted for expenditure data that was not accounted by SNAP benefits, such as cash.

In the present study, interpretation of grocery receipts in this study was based solely on expenditure data. Spending patterns at the household level may not necessarily reflect an individual's total dietary intake. Sekula et al. reported good agreement between data obtained from budget survey and consumption of potatoes, vegetables, meat, poultry, and animal fats; whereas, comparisons with other food groups were less [140]. Moreover, some food items represented in the receipts may not be consumed by the participant or other household members. Another limitation is that the cost of individual diets was not assessed which would be useful to determine diet expenditure and disease associations [141]. Finally, ambiguity may arise due to classification of different foods into specific food categories. For example, foods such as frozen pizza, frozen lasagna and frozen pot pie were classified jointly under one food category, frozen entrees. But the utilization of food categories helped define expenditure patterns due to the large number of foods present in grocery receipts.

This study focused on foods that are consumed primarily at home, and does not consider for foods purchased from restaurants and fast food establishments. Also foods might be obtained from sources that do not provide receipts, such as friends and family. Any changes in habitual shopping behaviors during the data collection period are also potential for bias. Finally, this research utilizes a relatively small sample size when compared to the participation of SNAP at a national level.

CONCLUSIONS

These results have important policy implications that emphasize the critical need to enhance the food purchasing behaviors of at-risk SNAP families. Comparison of food spending across several food categories specified those that were a predominant expenditure share of the TFP market basket. This study also implies that SNAP households may spend more on low fat dairy, vegetables, whole grains and fruits with increases in food purchasing power. Future research could focus on psychosocial factors associated with inadequate grocery spending. An understanding of factors involved in food selection decisions may help health professionals better design interventions that target SNAP participants.

Chapter 4: Monthly variations in dietary intake of women participating in the Supplemental Nutrition Assistance Program

ABSTRACT

To investigate the dietary intake of SNAP clients over 1 month, and to determine the influence of food insecurity on diet quality. Participants were administered a demographics questionnaire and a food frequency questionnaire (FFQ) based on a reference period of 1 week. The FFQ was completed four times, with an interval of 1 week, so that it reflected the diets of participants during weeks 1, 2, 3 and 4 of benefit receipt. They also completed the United States adult food security module. The Healthy Eating Index-2010 and the Dietary Guidelines Adherence Index 2015 were used to determine diet quality. A mixed linear model was conducted using time as the independent variable, and food group and nutrient intake and diet quality as the dependent variables. Women (n=151) participating in SNAP were recruited from low-income housing and neighborhood centers in Central Texas, USA. A significant decrease in daily intakes of fruits, vegetables, dairy and diet quality was observed over the month. Food secure women had higher diet quality than those with very low food security. However, a decline in diet quality was observed in all groups of women, classified according to food security status. These results show that dietary intake of SNAP participants varies based on time since receipt of benefits. Resource management education, evaluation of adequacy of benefits and bi-monthly distribution of benefits are

some policy measures that could mitigate the decrease in diet quality towards the end of the month.

INTRODUCTION

The Supplemental Nutrition Assistance Program (SNAP) is the largest food assistance program in the United States. This program provides financial aid to households with a gross income of ≤130% of the Federal Poverty Level to purchase food [142]. In 2015, SNAP approximately served 45.7 million Americans with program benefits of $69.6 billion [5]. The maximum monthly benefit that can be allotted to SNAP households is based on the Thrifty Food Plan [6]. The SNAP allotment is calculated as = maximum monthly benefit for a given household size – 0.3 × net income [142]. The net income is determined by subtracting expenses related to child support, emergency, dependent care, excess shelter, and out-of-pocket medical costs for the elderly and disabled from the gross income. Household benefits are credited once every month to an electronic benefit transfer card given to each SNAP-participating family. Many low-income families conduct major shopping trips only once every month, and majority of the food expenditure has been reported to occur within the first 3 days of distribution of benefits [13,14]. Then, approximately 80% of the benefits are redeemed within the first 2 weeks [15]. In an investigation conducted by Mabli et al., 80.2 and 50.6% of SNAP participants reported that their benefits lasted only 3 and 2 weeks, respectively [133], with an average of 2.7 weeks [133]. Similarly, Calloway et al. found that 81% of their study participants spent their SNAP benefits within 3 weeks [32]. Other studies also have demonstrated a decrease in food spending over the month as compared to week 1 of

receipt of benefits [134,143,144]. The decline in grocery expenditure may indicate limited food availability in SNAP households towards the end of the month, subsequently affecting dietary intakes.

According to the Continuing Survey of Food Intake by Individuals for 1989-1991, SNAP participants who depended on one grocery shopping trip for the month had stable energy intakes during the first three weeks [13]. This stability was followed by a decline in the fourth week [13]. Shapiro et al. also reported a 10 to 15% decrease in energy intake at the end of the month [33]; the decline indicated by Todd et al. was even larger (25%) [145]. In African American SNAP participants, Kharmats et al. found higher consumption of energy, fat and protein in the early and later stages of the monthly cycle of benefit distribution [35]. Another variance was documented by Hamrick et al. in which SNAP participants had a higher likelihood of reporting a day with no eating episodes than did non-participants over the 1-month period [34]. Collectively, these studies suggest that SNAP participants have diverse eating patterns during the monthly cycle of benefit distribution.

Low-income women may be vulnerable to food insufficiency to the point that they restrict their own diets in order to provide food for their families [146]. Both Campbell et al. and Matheson et al. have observed that mothers may compromise their own food intake in order to protect their children from insufficient food [147,148]. Also, McIntyre et al. found greater nutrient inadequacy in low-income, single mothers as compared to their children [146]. The disproportionately lower economic status of women when compared to men also places them at risk for consumption of poor quality diets [149]. Thus, it is

important to investigate how diet changes in response to fewer resources to purchase food towards the end of month. The primary goal of this study was to investigate food and nutrient intake, and diet quality of a population of women participating in SNAP over the monthly cycle. This research assumes significance in view of the 2013 cuts in the SNAP allotment, where a household of four lost an average of $36 of benefits [150].

Food insecurity is characterized by an inability to acquire nutritious food by socially acceptable means [1]. Although the SNAP assumes a central role in reducing food insecurity in low-income households, some program participants have been reported as being food insecure [30,151]. The moderating influence of food insecurity on diet quality based on time that has elapsed since receipt of benefits is unclear. A secondary goal of this research was to compare diet quality between food secure and food insecure women by two measures: the classic, Healthy Eating Index-2010 and the Dietary Guidelines Adherence Index 2015, a newer method developed in Canada.

METHODS

Design

Recruitment for the study was conducted at low-income housing sites and neighborhood centers from October 2014-December 2015. At visit 1, interested participants completed a demographics survey. Four more visits with 1-week intervals occurred at the data collection sites. At that time, subjects completed a food frequency questionnaire (FFQ) based on a reference period of 1 week. The days of completion of each FFQ were determined based on the date of receipt of SNAP benefits, as indicated in

the demographics survey. For example, a participant who received SNAP benefits on the first of every month completed the 1-week FFQ on days 8, 15, 22 and 29. Participants also completed the adult food security module during the final visit.

Subjects

Eligibility criteria for the study included: female, enrollment in SNAP, ages 18-50 years old, and Hispanic, African-American, or non-Hispanic White ethnicity. Women with serious illness or who were pregnant or lactating were not included. A total of 217 women who met the eligibility criteria participated in the study. However, 58 women were lost to attrition during follow up. In the remaining sample of 159 participants, eight subjects were excluded due to unreasonable caloric intakes that exceeded 4500 kcals. Thus, the final sample consisted of 151 subjects.

Demographic Questionnaire

A demographics survey developed by the author [132] was tailored to a population of low-income women. It collected information on ethnicity, age, household size, number of children, marital status, nationality, number of hours and type of physical activity per week, and date of receipt of SNAP benefits.

United States (U.S.) adult food security module

The 10-item U.S. adult food security module was used as a measure of food security [152]. The total score ranges from 0 to 10, with higher scores representing lower food security. The scoring utilized to classify individuals into different levels of food

security was: 0–2, food security; 3–5, low food security; and 6–10, very low food security.

Food frequency questionnaire

Dietary intakes were calculated from a food frequency questionnaire (FFQ). This FFQ has been validated for a sample of women enrolled in SNAP by comparison with 3-day diet records [153]. Test-retest reliability was assessed by administration of the FFQ twice, with an interval of 1 month. The mean validity correlation between the nutrients obtained from the FFQ and 3-day diet records was 0.61; whereas, the test-retest correlation between nutrients obtained from the two FFQ administrations was 0.66.

The FFQ consisted of 95 line items and was based on a reference period of one week, with frequency options ranging from never or less than once per week to 2+ times per week. The serving size options of the FFQ were small, medium, large and extra-large. Nutritionists trained in the dietary collection protocol provided in-depth instructions to help participants complete the FFQ, and taught estimation of portion sizes using food models and measuring cups and spoons.

The FFQs were administered to the participants once a week for 4 weeks. The dates of completion of the FFQ were pre-determined, and based on the day of receipt of SNAP benefits. For instance, an individual who received SNAP benefits on day 2 of each month completed the 1-week FFQ on days 9, 16, 23 and 30. The FFQs were checked for completeness and accuracy. Energy intakes that ranged from 500-4500 kcals were considered acceptable for women, and were used as the cut-off levels for this study. Out

of the 159 women who completed the study, data obtained from eight participants were excluded due to reporting of caloric intakes > 4500 kcals.

Dietary quality

Two measures of diet quality were utilized in this study: 1) The Healthy Eating Index-2010 (HEI-2010) [154] and 2) The Dietary Guidelines Adherence Index 2015 (DGAI 2015) [155]. The HEI-2010 is a comprehensive measure that provides a score, ranging from 0-100, based on adherence to key food group and nutrient intakes of the Dietary Guidelines for Americans 2010. This scale considers intakes for 12 dietary subgroups, consisting of nine adequacy and three moderation components. The second measure of diet quality, DGAI 2015, assigns a score ranging from 0 to one based on compliance to 11 food groups, with eight nutrient intake recommendations. The Estimated Energy Requirement (EER) for each individual was calculated from one of the eight United States Department of Agriculture (USDA) energy patterns, ranging from 1800-3200 kcal [155]. Index scores were calculated to represent adherence of actual intake to the recommendations of the respective energy pattern. The maximum possible score that represents the healthiest diet that could be obtained via this scale is 19.

Line items in the 1-week FFQ were categorized into food groups, according to the HEI-2010 and DGAI 2015. For both methods, mixed dishes were split into individual foods, and classified into the appropriate food categories. Sources used to determine serving sizes for foods were the Dietary Guidelines for Americans 2010 [63] and MyPlate [64]. Daily servings for each food group were calculated by multiplying the daily frequency

of consumption of individual foods in the food group by the chosen serving size, and summing across individual foods.

FoodWorks 17 software (Long Valley, NJ) [156] was used for calculation of nutrient data. This program includes nutrient information for 40,000 foods from databases such as the USDA Standard Reference 27 [67], Food and Nutrient Database for Dietary Studies [68] and the Canadian Nutrient File 2010 [69]. The nutrient content of each line item, as determined from FoodWorks 17 software, was multiplied by the corresponding frequency of consumption. Nutrient values were summed across all the items in order to estimate daily nutrient intakes.

Scores were assigned to each component of the HEI-2010 and DGAI 2015 by linear equations [154], and summed to represent overall diet quality.

Statistical Analysis

Descriptive statistics were used to describe the demographic profile of the participants. Changes in food group, nutrient intake, and diet quality between the four weekly time points were assessed by a mixed linear model. Pairwise comparisons using Bonferroni adjustment were carried out when significant main effects were detected. Additionally, an analysis of variance was conducted to determine differences in diet quality according to the level of food security for each week. A $p\text{-value}<0.05$ was considered significant. Statistical analyses were performed using Statistical Package for Social Sciences (SPSS, Version 22) [157].

RESULTS

Demographics

The demographic characteristics of the participants are presented in Table 4.1. The majority were Hispanic, with a mean age of 35 years. Household size and number of children ranged from 1 to 8 and 0 to 5, respectively. More than half of the women were single or divorced, and born in Mexico. Moreover, 92 participants were classified as food insecure based on the score derived from the U.S. adult food security module.

Nutrient intake

Table 4.2 shows the mean daily nutrient intake for each week of the study. A significant effect of time on daily intakes was found for all nutrients, with the exception of carbohydrates, saturated fat, polyunsaturated fat, folate and iron. Pairwise comparisons indicated that energy intake was significantly reduced in week 3, as compared to week 1. However, the percentage of calorie consumption accounted by protein was significantly lower, whereas that for energy from fat was significantly higher in week 4 when evaluated against other time points. Between-week comparisons for other nutrients whose daily intakes were influenced by time indicated that fiber, cholesterol, vitamins A, C, D and E, zinc, calcium and potassium were significantly higher in week 1, than in weeks 3 and 4. In contrast, sodium consumption was higher in week 4.

Table 4.1. Demographic profile of women participating in the Supplemental Nutrition Assistance Program (n=151)

Demographic characteristic	**Percentage of participants**
Race/ ethnicity	
Hispanic	68.7
Non-Hispanic White	10.7
Non-Hispanic Black	20.6
Age (years)	
19-30	25.0
31-40	54.7
41-50	20.3
Household size	
<3	29.5
3-5	65.8
>5	4.7
Number of children	
None	11.4
1-3	82.6
>3	6.0

Table 4.1. Continued

Marital status	
Single/Divorced	55.4
Married/Living with partner	44.6
Place of birth	
United States	41.7
Mexico	58.3
Food security status	
Food security	39.1
Low food security	30.5
Very low food security	30.5

Table 4.2. Mean daily energy and nutrient intakes of women participating in the Supplemental Nutrition Assistance Program (n=151) during the four weeks of the monthly benefit distribution cycle

Nutrient	Dietary reference Intakes	Nutrient intake per day*			
		Week 1	Week 2	Week 3	Week 4
Energy (kcal)	-	2511±67.4[a]	2290±64.7	2143±54.9[b]	2350±66.8
Carbohydrates (% kcal)	45-65	51±0.6	52±0.6	52±0.5	51±0.7
Protein (% kcal)	10-35	20±0.2 [a]	20±0.2 [c]	20±0.2[x]	18±0.2 [b,d,y]
Total fat (% kcal)	20-35	33±0.3 [a]	33±0.4 [c]	33±0.4 [x]	35±0.4 [b,d,y]
Saturated fat (% kcal)	<10	12±0.2	12±0.2	12±0.2	12±0.2
Polyunsaturated fat (% kcal)	6-11	6±0.5	6±0.5	6±0.4	6±0.6
Fiber (g)	25	20.6±0.7 [a,c]	19.5±0.7 [x]	17.5±0.6 [b]	16.6±0.6 [d,y]
Cholesterol (mg)	-	420±15.8 [a,c]	369±14.4	327±12.2 [b]	338±12.7 [d]
Vitamin A (μg)	700	657±22.8 [a,c]	617±22.9 [x]	546±20.6 [b]	501±19.5 [d,y]
Vitamin C (mg)	75	124±6.2 [a,c]	113±5.9 [x]	100±5.4 [b]	77±4.5 [d,y]
Vitamin D (μg)	15	5.3±0.21 [a,c]	4.8±0.18 [x]	4.3±0.16 [b]	4.0±0.17 [d,y]
Vitamin E (mg)	15	8.5±0.32 [a,c]	8.0±0.28	7.2±0.26 [b]	7.3±0.26 [d]
Thiamin (mg)	1.1	2.6±0.1 [a]	2.4±0.1	2.3±0.1 [b]	2.4±0.1

Table 4.2. Continued

Riboflavin (mg)	1.1	2.9±0.1 [a,c]	2.7±0.1	2.6±0.1 [b]	2.6±0.1 [d]
Niacin (mg)	14	35.5±1.1[a]	32.4±1.0	31.0±0.9 [b]	32.5±1.0
Folate (μg)	400	650±19.0	625±19.3	619±18.4	603±18.6
Calcium (mg)	1000	1050±31.5 [a,c]	961±28.9 [x]	878±25.9 [b]	840±26.3 [d,y]
Iron (mg)	18	23.0±0.6	22.2±0.6	21.2±0.6	22.5±0.6
Zinc (mg)	8	16.7±0.5 [a,c]	15.4±0.5	13.8±0.4 [b]	14.5±0.4 [d]
Manganese (mg)	1.8	3.9±0.1 [a,c]	3.7±0.1	3.3±0.1 [b]	3.2±0.1 [d]
Sodium (mg)	2300	3750±122.68	3565±116.56	3438±102.35 [a]	3883±126.58 [b]
Potassium (mg)	4700	3711±32.9 [a,c]	3411±29.7 [x]	3098±27.2 [b]	2962±27.9 [d,y]

*Data are presented as Mean±standard error of mean

[a,b]Mean values with superscript letters (a) and (b) are significantly different at the 0.05 level, according to Bonferroni-adjusted pairwise comparisons

[c,d]Mean values with superscript letters (c) and (d) are significantly different at the 0.05 level, according to Bonferroni-adjusted pairwise comparisons

[x,y]Mean values with superscript letters (x) and (y) are significantly different at the 0.05 level, according to Bonferroni-adjusted pairwise comparisons

Food group intake

Table 4.3 shows the unadjusted daily mean servings of food group intake for each week from receipt of SNAP benefits. A significant decrease was observed in servings of fruits, vegetables, whole grains, and dairy, with an increase in time since distribution of SNAP benefits. Pairwise comparisons showed that the average consumption of these food groups was significantly lower at the end of the month, as compared to the beginning. In contrast, the intake of refined grains was found to be highest in week 4, and significantly greater than consumption at week 3.

Diet quality

Diet quality from both measures significantly decreased towards the end of the month. Table 4.4 shows that HEI-2010 scores in weeks 3 and 4 were significantly lower than the earlier stages of the SNAP cycle. On the other hand, the overall DGAI 2015 score remained relatively stable for the first 3 weeks, with a significant drop in week 4 as compared to week 1.

Food insecurity and diet quality

Figures 4.1a and 4.1b represent the HEI-2010 and DGAI 2015 diet quality scores of women participating in SNAP, as classified according to food security status for weeks 1, 2, 3 and 4. Diet quality obtained from both measures was significantly lower in week 4 when compared to other weeks for food secure, low food secure and very low food secure women. The interaction between time and food security status on diet quality scores were

Table 4.3. Mean daily servings of food groups in women participating in the Supplemental Nutrition Assistance Program (n=151) during the four weeks of the monthly benefit cycle

Food group	**Food group servings per day***			
	Week 1	**Week 2**	**Week 3**	**Week 4**
Fruit (cups/d)				
Total	1.45±0.07[a,c]	1.34±0.06[x]	1.18±0.06[b]	0.84±0.05[d,y]
Whole	0.99±0.05[a]	0.91±0.05[c]	0.83±0.05[x]	0.59±0.05[b,d,y]
Vegetables (cups/d)				
Total	1.77±0.08[a,c]	1.71±0.08[x]	1.46±0.07[b]	1.26±0.06[d,y]
Dark green	0.11±0.01[a]	0.09±0.01	0.09±0.01	0.05±0.01[b]
Orange	0.25±0.02[a]	0.22±0.02[c]	0.20±0.02	0.13±0.01[b,d]
Legumes	0.36±0.03	0.36±0.03	0.34±0.03	0.29±0.03
Starchy	0.41±0.03	0.40±0.03	0.33±0.02	0.37±0.02
Other	0.64±0.04 [a,c]	0.63±0.04 [x]	0.51±0.03[b]	0.42±0.03 [d,y]
Grains (oz/d)				
Whole	0.99±0.10[a]	0.88±0.09[c]	0.73±0.09	0.49±0.06[b,d]
Refined	6.93±0.24	6.50±0.24	6.35±0.22[a]	7.30±0.28[b]

Table 4.3. Continued

Dairy (cups/d)				
Total	2.07±0.08[a,c]	1.89±0.08[x]	1.67±0.07[b]	1.16±0.06[d,y]
Low fat[‡]	0.09±0.01[a]	0.08±0.01[c]	0.08±0.01[x]	0.05±0.01[b,d,y]
Protein foods (oz/d)				
Total	8.74±0.28[a,c,x]	7.69±0.29[b]	7.15±0.23[d]	7.49±0.27[y]
Seafood and plant	0.84±0.09[a]	0.67±0.07	0.60±0.07	0.45±0.05[b]

*Data are presented as Mean±standard error of mean

[a,b]Mean values with superscript letters (a) and (b) are significantly different at the 0.05 level, according to Bonferroni-adjusted pairwise comparisons

[c,d]Mean values with superscript letters (c) and (d) are significantly different at the 0.05 level, according to Bonferroni-adjusted pairwise comparisons

[x,y]Mean values with superscript letters (x) and (y) are significantly different at the 0.05 level, according to Bonferroni-adjusted pairwise comparisons

Table 4.4. Two measures of diet quality of a sample of women participating in the Supplemental Nutrition Assistance Program (n=151) by weeks of the monthly cycle of benefit distribution.

Diet quality measure	Week 1*	Week 2	Week 3	Week 4
Healthy Eating Index-2010[29]	57.40±0.90 [a,c]	56.22±0.93 [x]	53.51±0.95 [b]	45.57±1.00 [d,y]
Dietary Guidelines Adherence Index 2015[43]	7.24±0.18 [a]	7.22±0.18	7.00±0.17	5.93±0.16 [b]

*Data are presented as Mean±standard error of mean

[a,b]Mean values with superscript letters (a) and (b) are significantly different at the 0.05 level, according to Bonferroni-adjusted pairwise comparisons

[c,d]Mean values with superscript letters (c) and (d) are significantly different at the 0.05 level, according to Bonferroni-adjusted pairwise comparisons

[x,y]Mean values with superscript letters (x) and (y) are significantly different at the 0.05 level, according to Bonferroni-adjusted pairwise comparisons

not significant. However, a trend of consistently higher diet quality was found for those who were food secure. Figure 4.1a indicates that food secure women had significantly greater HEI-2010 diet quality scores than those with very low food security at weeks 3 and 4, according to pairwise comparisons (p-value<0.05). A similar pattern was observed for the DGAI 2015 scores (Figure 4.1b); but differences were not significant.

DISCUSSION

This study extends previous research by the use of a longitudinal design to examine dietary variations in SNAP participants. As expected, diet quality declined with time from receipt of benefits. The average HEI-2010 score over the 4 weeks (53.0) was somewhat higher than values reported by others that used a similar measure in adult SNAP participants [47.6, Condon et al. [65] and 42.6, Nguyen et al. [158]]. In terms of the DGAI 2015, the mean score for weeks 1, 2, 3 and 4 were 7.2, 7.2, 7.0 and 5.9, respectively, indicating suboptimal dietary intakes among SNAP participants [155]. Comparison of DGAI 2015 scores of the present study with previous research is not available as it is a relatively new measure of diet quality.

The proportion of women who were classified as food insecure in this study (61%) is comparable to that reported by Mabli et al. (60.7%) in a nationally representative sample of households that were evaluated six months after SNAP enrollment [30]. Women experienced a decline in diet quality as benefits were spent, irrespective of their food security status. However, those who were food secure had significantly higher HEI-2010 score at weeks 3 and 4 as compared to women with very low food security. The lack of significance of this pattern with the DGAI 2015 instrument

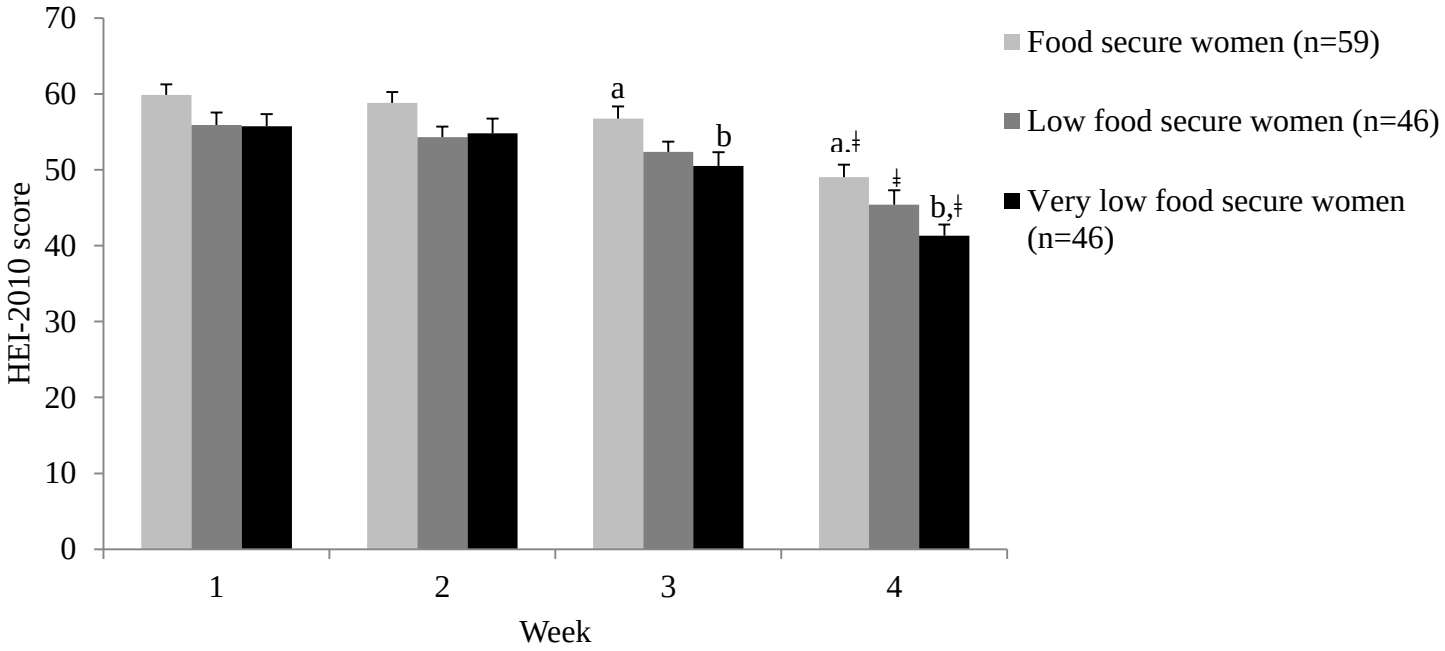


Figure 4.1a. Diet quality, as measured by HEI-2010, of female Supplemental Nutrition Assistance Program participants (n=151), classified food security status. Data are represented as mean±standard error of mean.

HEI-2010, Healthy Eating Index-2010

[a,b] Mean HEI-2010 score for superscript (a) is significantly higher ($p < 0.05$) than mean with superscript (b), according to Bonferroni-adjusted pairwise comparisons

[‡] Mean HEI-2010 score in week 4 is significantly lower than weeks 1, 2 and 3 for food secure, low food secure and very low food secure women ($p < 0.05$), according to Bonferroni-adjusted pairwise comparisons

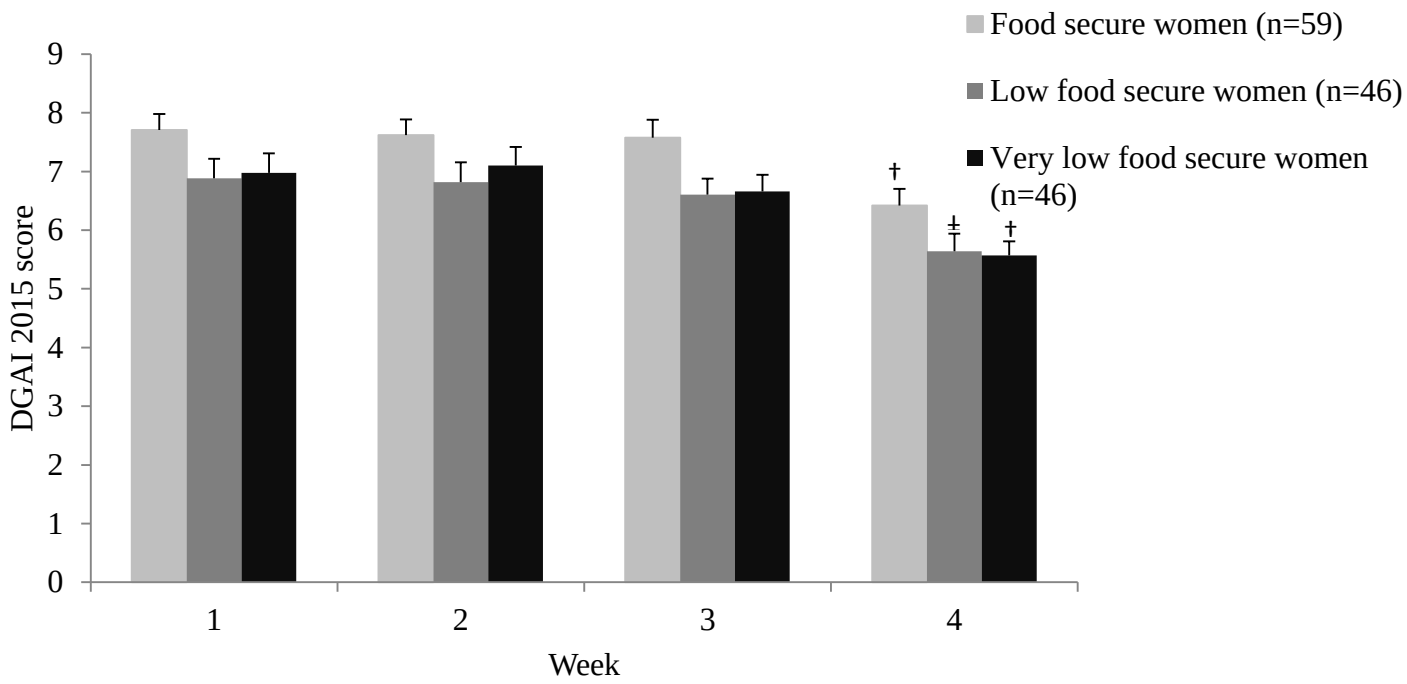


Figure 4.1b. Diet quality, as measured by DGAI 2015, of female Supplemental Nutrition Assistance Program participants (n=151), classified food security status. Data are represented as mean±standard error of mean.

DGAI 2015, Dietary Guidelines Adherence Index 2015

[‡] Mean DGAI 2015 score in week 4 is significantly lower than weeks 1, 2 and 3 for food secure and very low food secure women ($p < 0.05$), according to Bonferroni-adjusted pairwise comparisons

[†] Mean DGAI 2015 score in week 4 is significantly lower than weeks 1 and 2 for low food secure women ($p<0.05$)

could be attributed to differences in key components and the scoring scales between the two measures. For example, the total possible scores for each component of the DGAI 2015 ranged from 0 to 19; whereas possible scores of HEI-2010 could be between 0 and 100. Additionally, the DGAI 2015 and HEI-2010 measures 19 and 12 dietary components, respectively. Moreover, the HEI-2010 food group scores are based on intakes per 1000 kcal. Nevertheless, the percentage decrease in diet quality from weeks 1 to 4 was fairly comparable between the two scales. The decline for the diet quality score using the measures of DGAI 2015 and HEI-2010 was 16.7% vs 18.1% for the food secure, 18.1% vs 18.8% for low food secure, and 20.2% vs 25.9% for very low food secure women, respectively. To the best of our knowledge, this is the first study to investigate changes in diet quality over time based on food security status in women participating in SNAP.

A decrease in the consumption of fruits, vegetables and dairy foods with time from receipt of benefit was observed in this study. In contrast, Kharmats et al. did not find similar eating patterns for fruits and vegetables [35]. One explanation for this discrepancy could be the ethnic differences in samples; Kharmats et al. focused on African Americans, while the majority of participants in this study were Hispanic. A number of investigations have reported greater fruit and vegetable intake in Hispanics as compared to African Americans [159,160]. Consequently, fruit and vegetable intake in Hispanics might be more likely to be affected adversely by exhaustion of SNAP benefits towards the end of the month. Yet, refined grain intake followed a different trend, with intakes being the highest at the end of the month. The relatively non-perishable nature of

grain products [161] and inexpensive cost [9] may help explain their increased intake during the latter phase of the SNAP cycle.

Energy intake declined from weeks 1 to 3, followed by a slight increase. The percentage of calories from protein was lowest at week 4; while energy from fat was at its highest level. Fiber and several micronutrients declined, with the exception of folate and iron. Participants did not meet the DRI for fiber, Vitamins A, D, and E, calcium and potassium. Calcium intake was adequate at the beginning of the month, and then decreased with every succeeding week from benefit distribution. In contrast to Hilmers et al. who reported inadequate iron intakes in Hispanic women enrolled in SNAP [162], this study observed iron intakes to be higher than recommendations. The number of servings of protein foods in this sample of participants was greater than that found by Hilmers et al, and could be related to the increased iron values.

Sodium and saturated fat intakes exceeded the recommendations for each of the four time points in the present study. This research also found that cholesterol intake was greatest during the first week of the month. Low-income women have commonly cited meat as the most essential food item for consumption [163]. Thus, SNAP participants may prioritize purchasing of meat when benefits are first distributed. Consistent to this finding, meat intake was higher at week 1, presumably contributing to higher cholesterol and iron intakes at the beginning of the monthly cycle. The greater dairy intake in week 1 also could explain the higher cholesterol values at this stage.

The FFQ was based on a reference period of one week which may make it easier to recall diets. Yet, a limitation is that food frequency questionnaires may lack specificity. Unlike diet records and dietary recalls where participants provide a detailed description of foods, the FFQ only offers a standard check list of line items, frequency of consumption and portion sizes. Additionally, responses to a FFQ rely on longer-term memory of the participants, as compared to other methods of diet evaluation. Since the study required multiple measurements of diets of SNAP participants, the 1-week FFQ was chosen as the method to assess nutrient intake in order to decrease subject burden. Also, the food security module was administered at the end of the monthly SNAP cycle, a time when participants were more likely to be food insecure. Moreover, the number of days since receipt of SNAP benefits was used as a proxy for household food availability, with no direct indicators of this measure. Finally, the high proportion of Hispanic participants in this study limits the generalizability of the results to other ethnic groups.

CONCLUSION

Women participating in SNAP are at risk for poor quality diets, with a notable decrease during week 4 of the monthly cycle. Resource management education, evaluation of adequacy of benefits and bi-monthly distribution of benefits are some policy measures that could mitigate the decrease in diet quality. Nutrition education that focuses on achievement of a healthy diet within a budget and efficient utilization of program benefits may help for the food supply to last through the month. The change of the monthly benefit distribution to twice a month might even out the food supply. However, this policy might be problematic for families that live in environments with

poor access to grocery stores who restrict their shopping trips to once a month. Future research should evaluate barriers associated with grocery shopping trips in SNAP participants for informed policy making.

Chapter 5: Food insecurity, diet quality and body mass index of low-income women participating in the Supplemental Nutrition Assistance Program: The mediating role of psychological, environment and social factors

ABSTRACT

Obesity and food insecurity are public health problem that disproportionately affect low-income populations, especially women participating in the Supplemental Nutrition Assistance Program (SNAP). An understanding of the factors that mediate the relationship between food insecurity and obesity is vital for public health interventions that target this population. The goal of this study was to determine the impact of psychological, home environment, community and social factors on diet quality and body mass index in women participating in SNAP. A total of 152 women receiving SNAP benefits were recruited from low-income neighborhood centers and housing communities, and administered a demographics questionnaire, multi-dimensional home environment scale (MHES), and measured for height and weight to calculate body mass index (BMI). Participants also completed the United States adult food security scale. A hierarchical regression analysis was conducted to develop a model for BMI and diet quality that utilized the MHES, after controlling for demographic characteristics. Differences in MHES scores between food secure and food insecure women were determined by an independent samples t-test. Finally, a mediation analysis using Hayes' process was performed to identify factors of the MHES that mediated the relationship

between food insecurity and BMI. Emotional eating resistance, availability of unhealthy food at home, neighborhood safety and social eating were inversely associated with BMI in women participating in SNAP (p-value<0.001); whereas emotional eating resistance and social eating were positively associated with diet quality (p-value<0.01). Individual, home environment, community and social factors measured by the MHES significantly mediated the relationship between food insecurity and body mass index of women in SNAP. Identification of components linked to diet quality and body mass index will help with development of interventions that aim to improve lifestyle behaviors in low-income women.

INTRODUCTION

Food insecurity is a public health problem that affects economically disadvantaged households [1]. The Supplemental Nutrition Assistance Program (SNAP), formerly Food Stamps, has been successful in reducing food insecurity in the U.S., but more than half of SNAP-participating households are still food insecure [30]. In contrast to the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) [164], the SNAP does not require purchasing of foods that are aligned to the Dietary Guidelines for Americans. Rather, SNAP benefits allow the purchase of most foods and beverages, with the exception of alcohol, tobacco, dietary supplements, and hot or prepared foods [108]. Moreover, SNAP participants have been reported to consume diets of lower quality characterized by fewer whole grains and more red meat, potatoes and fruit juice as compared to other income-eligible nonparticipants [165]. Additionally, the majority of

research has observed that women receiving SNAP benefits have a greater risk for obesity [24,26,29,49]. Thus, it is important to identify determinants of diet quality and body mass index in this population.

The Social Ecological Model (SEM) was the theoretical basis for this study since it proposes that health behaviors are governed by a variety intrapersonal, home environment, community and social factors [47]. The home environment and its dynamic interaction with multiple segments of the SEM play a critical role in shaping an individual's health behaviors. The first aspect to be explored within the context of the SEM is the intrapersonal component. Within this domain, psychological factors associated with eating behaviors will be investigated as these act as important determinants of diet quality and body mass index. Factors to be studied include emotional eating, self-efficacy, healthy eating attitudes and mindless eating. Eating in response to emotion and environmental cues, rather than hunger, was selected as it negatively impacts diet quality and body mass index of low-income women [166]. Self-efficacy, the confidence in one's abilities to engage in a certain action [167], also has been identified as a key predictor for adopting healthful practices associated with weight loss [168,169] and management [170]. Another critical factor is positive attitude towards healthy eating, as this has been strongly correlated to body mass index (BMI) of low-income women [171]. Finally, mindless eating has been associated with consumption of greater than intended quantities of food [172], and thus also may influence diet quality and weight status.

The second major component of the SEM considered was the environment, both home and community. The home is a critical part of the interpersonal environment for

nutrition, as a major portion of daily energy consumption occurs here [20], and the type of foods available is a key determinant of dietary intake [19]. Gorin et al. have shown that availability of healthy foods was lower, and that of unhealthy foods was higher in overweight individuals when compared to those who were normal weight [173]. The community, such as physical characteristics of the built environment (i.e. walkability, neighborhood safety) also affects health behaviors [174]. These were evaluated in this research since low-income populations often reside in neighborhoods that may offer limited opportunities for physical activity [175,176]. Finally, social factors such as adoption of positive family meal practices, social eating, social support, and descriptive norms for healthy eating (i.e. perceptions of eating behaviors of other individuals) were included due to their association with dietary behaviors [22].

The primary goal of the study was to assess the influence of psychological, home environment, community and social factors on diet quality and body mass index of SNAP participants. A secondary goal was to explore how these factors mediated the relationship between food insecurity and diet quality, and body mass index of women participating in SNAP.

MATERIALS AND METHODS

Study design and participants

A convenience sample of 152 women were recruited from low-income housing and community centers. Primary enrollment criteria included: participation in the SNAP program, ages 18-50 years old, and Hispanic, non-Hispanic White or African-American

ethnicity. Informed consent was obtained and participants were administered the demographics questionnaire, food frequency questionnaire, Multidimensional Home Environment Scale (MHES), and U.S. Adult Food Security Scale. In addition, women were measured for height and weight.

This study was granted an exempt status by the Institutional Review Board at The University of Texas at Austin, based on 45 46.101 (b)(2) Code of Federal Regulations. Participation in the study was voluntary and informed consent was obtained from all.

Demographics

A demographics questionnaire [132] tailored to a population of low-income women was modified to collect information pertaining to age, household size, number of children, ethnicity, monthly income, and amount of benefits received from SNAP per month.

U.S. Adult Food Security Scale

Food security status of participants was evaluated by the U.S. Adult Food Security Scale [152]. The summation of affirmative responses to the 10 questions in the scale represented the total score, with higher scores representing lower food security. Women with scores ranging from 0 to 2 were classified as food secure; whereas, those with scores between 3 and 10 were categorized as food insecure.

Food frequency questionnaire

A 95-item food frequency questionnaire (FFQ) that had been tested for validity and reliability in sample of women enrolled in SNAP was used to collect dietary intakes [153]. The mean validity correlation between the FFQ and reference instrument was 0.61; whereas, the test-retest correlation the two FFQ administrations was 0.66. The FFQ was based on a reference period of one week, with frequency options ranging from never or less than once per week to 2+ times per week. The FFQs were self-administered by participants once a week for 4 weeks. The serving size options of the FFQ were small, medium, large and extra-large. Trained nutritionists provided detailed instructions and showed food models and measuring cups and spoons in order to facilitate estimation of portion sizes.

Dietary quality

The Dietary Guidelines Adherence Index 2015 (DGAI 2015) [155] was used as a measure of diet quality. A score from 0 to 19 was assigned based on adherence of dietary intakes to 20 main dietary recommendations. Of the 20 subgroups, 11 components of the DGAI 2015 assess energy-specific food intake recommendations and 9 components evaluate healthy choice nutrient recommendations. The Estimated Energy Requirement (EER) for each individual was calculated from one of the eight United States Department of Agriculture (USDA) energy patterns, ranging from 1800-3200 kcal [155]. The maximum possible score that represents the healthiest diet in this scale is 19. Line items in the 95 FFQ were classified into food groups, according to DGAI 2015. Intake for each food

group was determined by multiplying the daily frequency of consumption of individual foods in the food group by the chosen serving size, and summing across individual foods. FoodWorks 17 software (Long Valley, NJ) [156] was used for calculation of nutrient data. This program includes nutrient information for 40,000 foods from databases such as the USDA Standard Reference 27 [67], Food and Nutrient Database for Dietary Studies [68] and the Canadian Nutrient File 2010 [69]. Scores were assigned to each component of the DGAI 2015 by linear equations [154], and summed to represent overall diet quality.

Anthropometrics

A stadiometer (Health O Meter, McCook, Illinois) and digital weighing scale (Health O Meter, McCook, Illinois) were utilized to measure height and weight, respectively. Body mass index (BMI), calculated as weight (kg)/height (m) ^{2}, was used to group women according to their body mass index. A BMI of $\leq$24.9 kg/m^2, 25-29.9 kg/m^2, and $\geq$30 kg/m^2 indicated healthy, overweight and obese status, respectively.

Multidimensional Home Environmental Scale

The MHES was created to comprehensively measure intrapersonal, environmental and social factors that influence body mass index in individuals [177]. The performance of this instrument was evaluated in a sample of 114 mother-child dyads, and demonstrated high construct validity, internal consistency reliability(α=0.83) and test-retest reliability (r=0.91). The version of the MHES questionnaire that was developed for mothers was utilized for this research. Psychological constructs of this tool include healthy eating attitudes, self-efficacy, emotional eating resistance, and mindless eating. Factors used to

assess the environmental influence on body mass index were availability of healthy foods at home, availability of unhealthy foods at home, neighborhood characteristics, and neighborhood safety. Finally, social aspects of the scale comprised of questions regarding regulation of family meals, social eating, social support and descriptive norms. The questions were based on a Likert scale with response options ranging from 'Strongly agree' to 'Strongly disagree', and the least and highest possible scores were 1 and 5, respectively. The items were reverse coded, as necessary, such that a higher score indicated a positive health behavior. For example, a response of 'Strongly disagree' to an item within the subscale, availability of unhealthy foods, was provided a score of 5. The response to each item within a subscale was summed to represent the subscale score.

Statistical analyses

Descriptive statistics were utilized to indicate demographic characteristics. Regression analysis was carried out to determine the influence of food security status and socio-demographics on overweight/ obesity. A univariate regression was conducted using the MHES subscale scores as the independent variables and BMI as the dependent variable. Then, a stepwise linear regression was conducted, using the MHES subscale scores that were significant from the univariate regression. The standardized β coefficient and p-value for each subscale were determined. Independent variables with a p-value less than 0.05 were considered to be significant predictors of body mass index. A similar analysis was performed to determine the influence of MHES constructs on diet quality. An independent-samples t-test was used to ascertain any differences in MHES subscale scores between food secure and food insecure women.

A mediation analysis was conducted to explore the relationship between food insecurity and body mass index. The psychological, environmental and social subscales of the MHES were aggregated to indicate the total score. A mediation analysis was conducted to explore the relationship between food insecurity and body mass index, using the total MHES score as the mediator variable. The Hayes' PROCESS macro [178] was utilized for this analysis. This consisted of food security status as the independent variable, BMI as the dependent variable, and the chosen MHES subscales as the mediators. The following conditions were tested in order to develop the mediation model: 1) significant association between the independent and mediator variables; 2) significant association between the independent and outcome variables; and 3) significant association between the mediator and outcome variables. If the above criteria were met, the total, direct and indirect effects of the model were analyzed. Total and direct effects denote the influence of the independent variable on outcome before and after inclusion of the mediator, respectively; whereas indirect effects represent the effect of the independent variable on mediator multiplied by that of the mediator on the outcome. The ratio of the indirect to total effect was used to indicate the proportion of the total effect moderated by the mediator. All analyses were performed using the Statistical Package for the Social Sciences (SPSS 22, Armonk, NY, 2013).

RESULTS

Demographic characteristics

The demographics of the study participants are shown in Table 5.1. The sample was predominantly Hispanic (71.1%) with age ranging from 19 to 50 years. The average household size and number of children in the household were 3.4 and 1.9, respectively. Monthly income and amount of benefits received from SNAP ranged from 0 to $3000 and $16 to $570, respectively. The proportion of women classified as healthy, overweight and obese were 28.9, 36.2 and 34.9, respectively.

Diet quality

Multidimensional radar plots were utilized to indicate the percentage of participants demonstrating different levels of compliance for the "food intake" and "healthy choice" components of the DGAI 2015 (Figure 5.1a and 5.1b). A score of greater than 0.5 of the maximum score was used to represent greater compliance, and was reported for 31%, 4.2%, 45.1%, 31.7%, 7.7%, 23.2%, and 7% of participants for fruits, dark green vegetables, red/orange vegetables, legumes, starchy vegetables, other vegetables and whole grains, respectively. This plot also demonstrated that proportion of participants with lesser compliance to saturated fat, cholesterol, and sodium recommendations were 82.4, 51.4 and 83.1, respectively.

Table 5.1. Demographic characteristics of women participating in SNAP[a] (n=152)

Demographic characteristic	**Median±SD[b]**
Age, yrs	35±8.30
Household size	3±1.39
Number of children	2±1.11
Monthly income, $	1402±732.71
Amount of benefits received from SNAP[a], $	240±111.53
Body mass index, kg/m^2	28.6±6.51

[a] Supplemental Nutrition Assistance Program

[b] Standard deviation

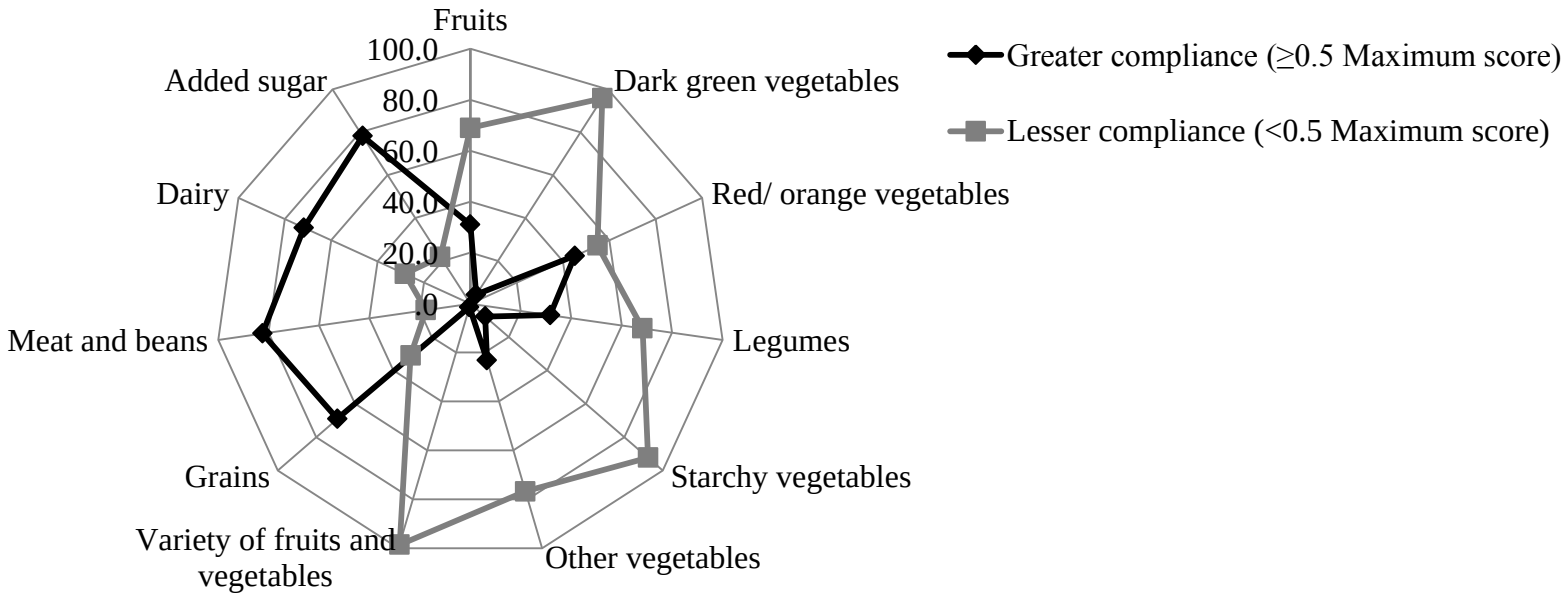


Figure 5.1a. Percentage of participants with greater and lesser compliance for the "food intake" subgroup components of the Dietary Guidelines Adherence Index 2015.

Each spoke of the plot represents a DGAI "food intake" component, and each line represents either greater or lesser compliance to the component. The largest outer circle represents 100% of participants, and the smallest circle represents 0% of participants. For example, participants with greater and lesser compliance to fruits were 31% and 69%, respectively.

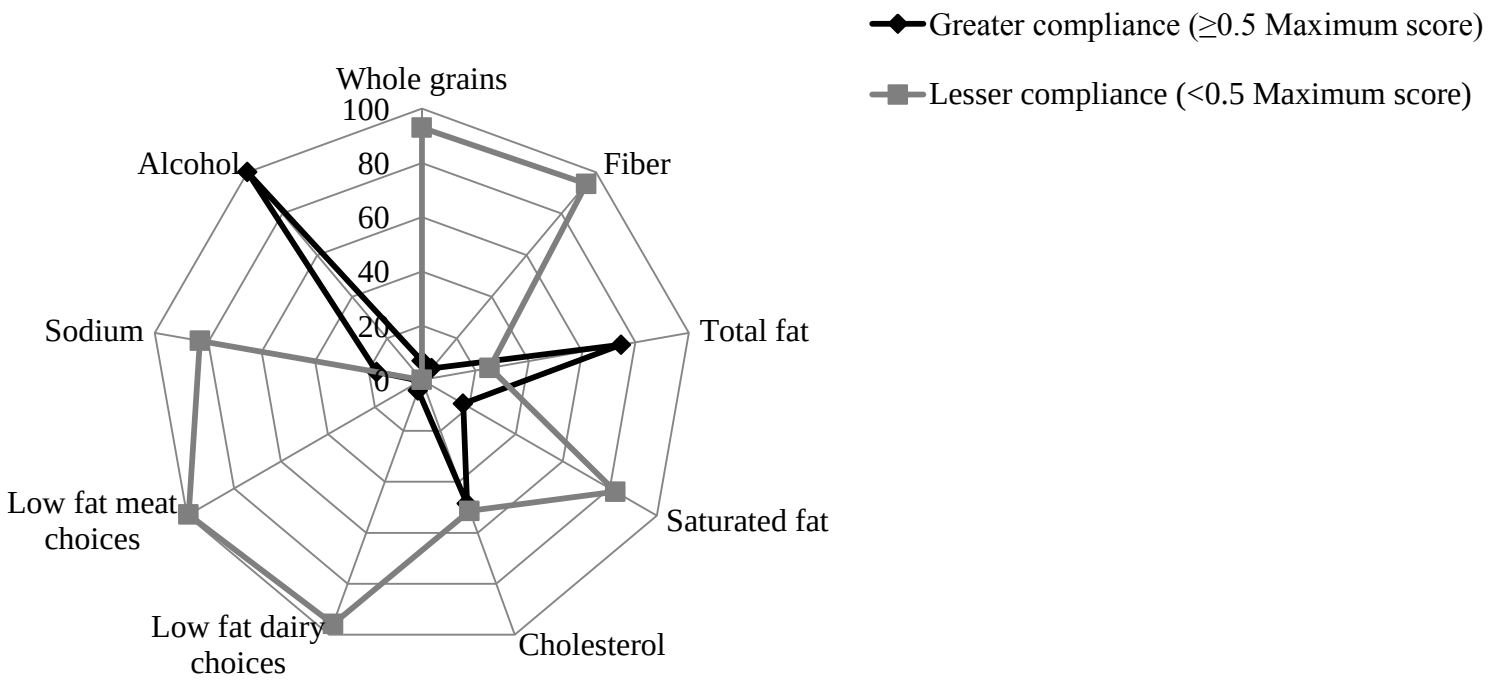


Figure 5.1b. Percentage of participants with greater and lesser compliance for the "healthy choice" subgroup components of the Dietary Guidelines Adherence Index 2015.

Each spoke of the plot represents a DGAI "healthy choice" component, and each line represents either greater or lesser compliance to the component. The largest outer circle represents 100% of participants, and the smallest circle represents 0% of participants. For example, participants with greater and lesser compliance to whole grains were 7% and 93%, respectively.

Association of MHES factors to diet quality and BMI of SNAP-participating women

Associations between intrapersonal, home environment, community and social factors, as measured by the MHES, and diet quality and BMI in SNAP participants are presented in Table 5.2. The relationship of MHES subscales to diet quality and BMI were tested in model 1, based on univariate regression analysis. Factors that were significantly linked to diet quality from the univariate regression analysis were emotional eating resistance, self-efficacy, healthy eating attitude, mindless eating, social eating and descriptive norms. These significant factors from model 1 were used for the subsequent stepwise linear regression analysis in model 2. Emotional eating resistance and social eating retained significance in model 2, explaining 14.8% of the variation in diet quality.

All factors measured by the MHES were significantly associated with BMI, with the exception of physical characteristics of neighborhood, regulation of family meals and descriptive norms. The predictors that remained significant in model 2 included emotional eating resistance, availability of unhealthy food at home, neighborhood safety and social eating. Collectively, these constructs explained 39.8% of the variance in BMI.

Influence of food insecurity on diet quality and BMI of women in SNAP

The percentage of women who were food secure and food insecure were 39.5 and 60.5, respectively. No significant differences were observed between food secure and food insecure women for demographic characteristics i.e. age, household size, number of children, monthly income and amount of benefits received from SNAP. Food insecurity was inversely related to diet quality of study participants (Adjusted $R^2 = 0.048$; $\beta =$

Table 5.2. Influence of multi-dimensional home environmental factors on BMI[a] and diet quality in women participating in SNAP (n=152)

Component	Diet quality				BMI			
	Model 1		Model 2		Model 1		Model 2	
	β	p-value	β	p-value	β	p-value	β	p-value
Healthy Eating Attitude	0.212	0.012	-	-	-0.256	0.002	-	-
Self-efficacy	0.137	0.038	-	-	-0.278	0.001	-	-
Emotional eating resistance	0.290	0.000	0.247	0.003	-0.422	0.000	-0.201	0.010
Mindless eating	0.168	0.046	-	-	-0.302	0.000	-	-
Availability of healthy food	0.164	0.052	-	-	-0.306	0.000	-	-
Availability of unhealthy food	0.135	0.112	-	-	-0.550	0.000	-0.287	0.001
Physical characteristics of neighborhood	-0.029	0.729	-	-	-0.128	0.117	-	-
Neighborhood safety	0.087	0.303	-	-	-0.496	0.000	-0.242	0.003
Regulation of family meals	0.011	0.897	-	-	-0.129	0.116	-	-
Social eating	0.314	0.000	0.259	0.002	-0.258	0.002	-0.164	0.017
Social support	0.006	0.945	-	-	-0.251	0.002	-	-
Descriptive norms	0.185	0.028	-	-	-0.137	0.098	-	-

[a]BMI = body mass index

-0.235; $p<0.01$), and positively associated with body mass index (Adjusted $R^2 = 0.039$; $\beta = 0.213$; $p<0.01$).

Food security status and MHES subscales

Participants classified as food secure scored higher than food insecure women in each component of the MHES, with the exception of regulation of family meals (Figure 5.2). The total MHES score was 5.6% greater in food secure women when compared to food insecure women. Moreover, a significant difference between the two groups was observed for availability of unhealthy food at home (p-value<0.001) and neighborhood safety (p-value<0.05). Food secure women scored higher than food insecure women for the subscales, availability of unhealthy food at home and neighborhood safety by 19.6% and 13.5%, respectively.

Mediation models

The results of the mediation analysis between food insecurity and diet quality are presented in Figure 5.3a. The impact of food insecurity on diet quality ($\beta=-0.46$, $p<0.01$) remained significant, even with inclusion of the MHES score as the mediator variable ($\beta=-0.38$, $p<0.05$). The estimate of the indirect effect was -0.08, with a confidence interval that ranged from -0.22 to 0.00. Since the confidence interval of the indirect effect included 0, the relationship between food insecurity and diet quality was not significantly mediated by the MHES.

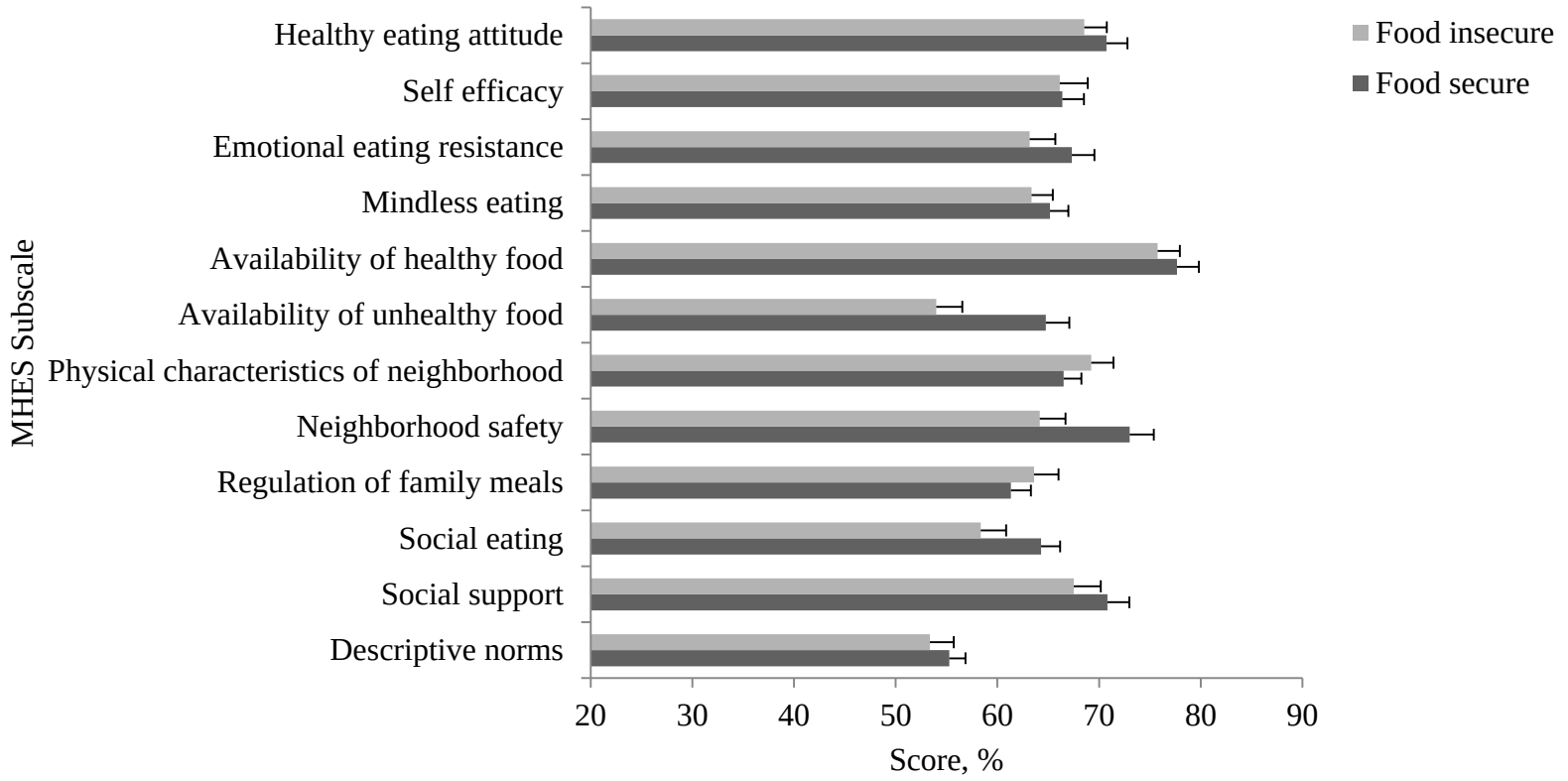


Figure 5.2. Multidimensional Home Environmental subscale scores (expressed as percentages) according to food security status in women receiving Supplemental Nutrition Assistance Program benefits (n=152).

Significant differences between food secure and insecure women was obtained for two subscales, availability of unhealthy foods at home and neighborhood safety (p-value<0.05).

In Figure 5.3b, the total effect of food insecurity on BMI was significant (β=0.42, $p<0.05$). However, when MHES score was included as mediator, this effect decreased and eventually lost significance (β=0.22). The accompanying reduction in the model was 47.6%. A significant estimate for the indirect effect was obtained where zero did not fall between the confidence intervals (β=0.19, 95% CI: 0.01-0.42). Thus, the MHES significantly mediated the association between food insecurity and body mass index.

DISCUSSION

The results of this study suggest that the MHES (psychological, home environment, community and social factors) significantly mediated the relationship between food insecurity and BMI of women participating in SNAP. Food insecurity appeared to be associated with a less favorable MHES score, which in turn, was related to higher BMI in women. The prevalence of food insecurity in the recruited sample was 60.5%, which is comparable to that found in a nationally representative sample of SNAP households [30]. An inverse link between food insecurity and diet quality in women participating in SNAP also was observed, thereby corroborating results from previous studies [179,180].

This research indicates that the percentage of participants who showed greater compliance were lower than those with lesser compliance for components of the DGAI 2015, including dark green vegetables, legumes, starchy vegetables, other vegetables, variety of fruits and vegetables, whole grains, and low fat dairy. Thus, the multi-dimensional radar plots indicate an under-consumption of these food groups. In contrast,

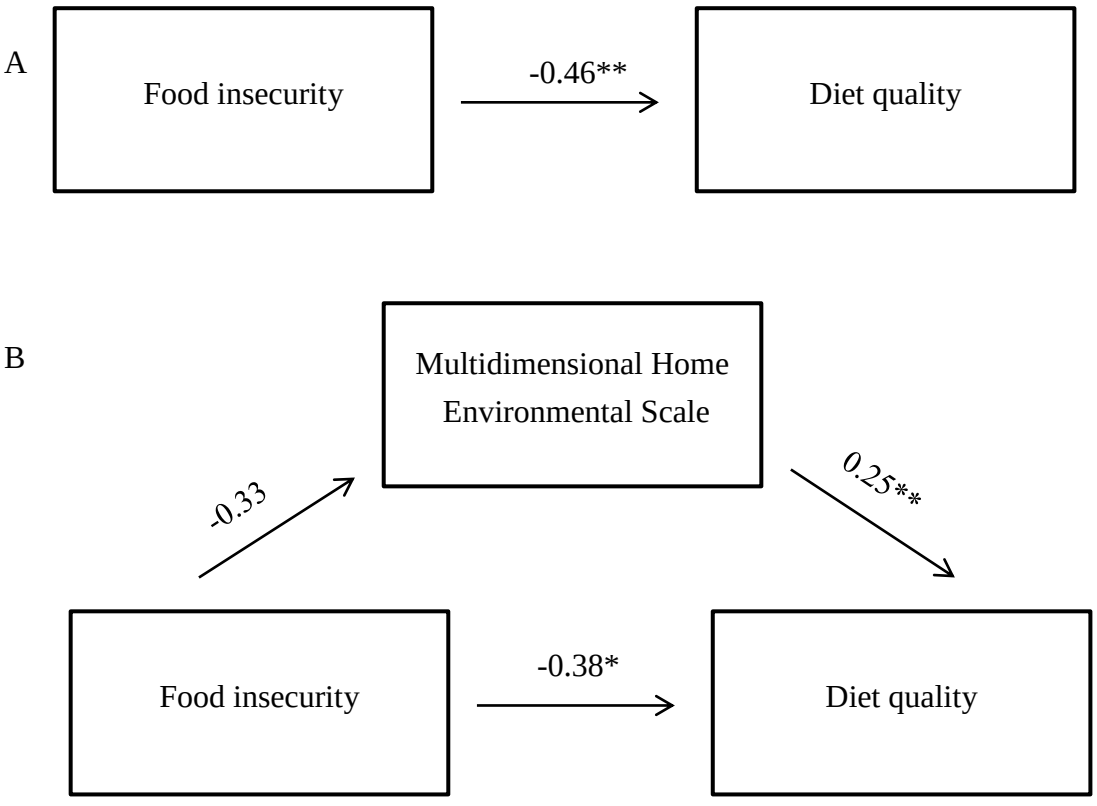


Figure 5.3a. Mediation of link between food insecurity and diet quality by the Multidimensional Home Environmental Scale

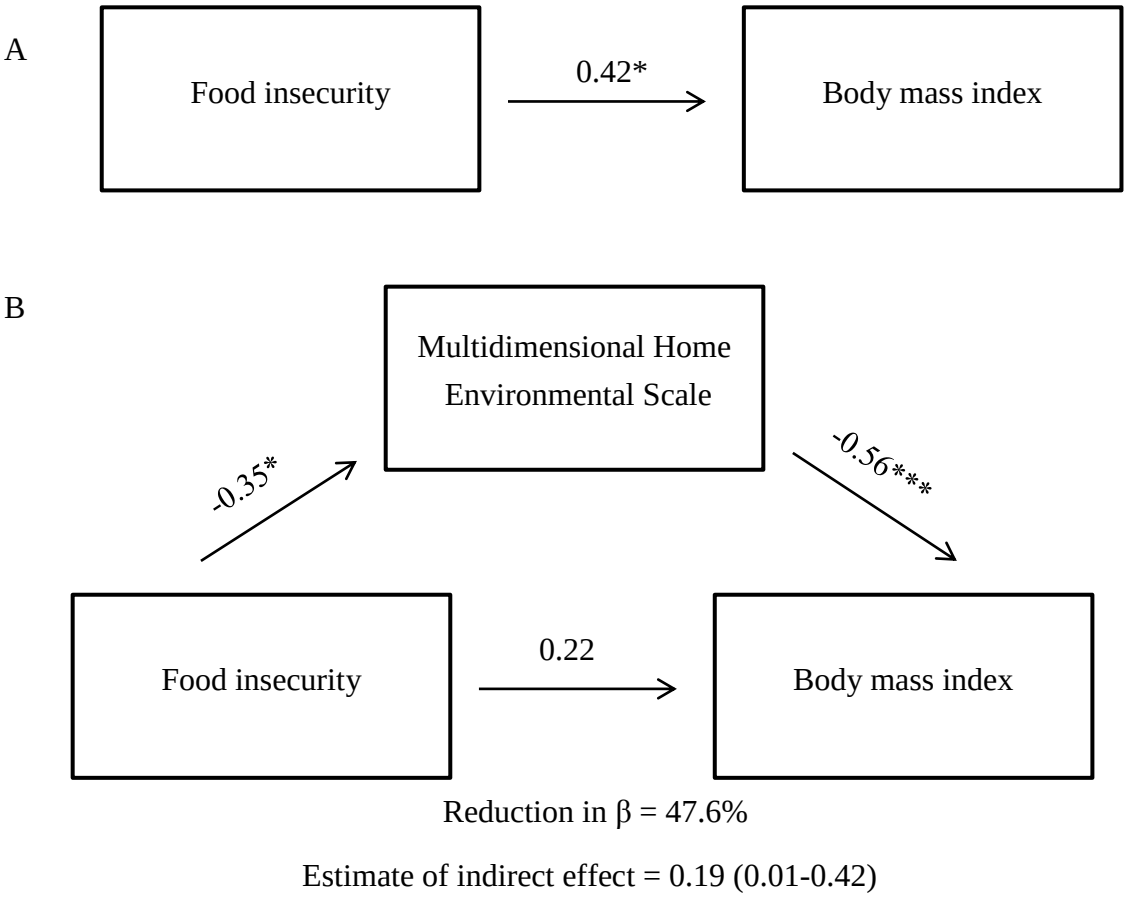


Figure 5.3b. Mediation of link between food insecurity and body mass index by the Multidimensional Home Environmental Scale

the higher proportion of women with lesser compliance for saturated fat, cholesterol, and sodium was attributed to the greater intakes of these nutrients.

The use of the MHES that comprehensively measured aspects related to the socio-ecological theory helped to identify factors that influence diet quality and BMI of female SNAP participants. Parallel to earlier investigations [181,182], this research observed that resistance to emotional eating was linked to greater diet quality and lower BMI. Low-income women have been shown to employ several strategies to manage their food resources, one of which includes the purchasing of energy-dense food items [183], such as cookies, chips, and soft drinks, due to their perceived lower cost and non-perishable nature [184-187]. This tendency to purchase poor quality foods may be greater among food insecure women due to financial constraints, and thus may explain the higher availability of these foods in their home environment. The negative impact of the availability of unhealthy foods on BMI, as demonstrated in the present investigation, indicates the need for a healthy home environment among SNAP families, especially for food insecure households.

Community characteristics assume a key role in modulating health behaviors of its residing population. The relationship between neighborhood safety and BMI in this study is consistent with that observed by Christman et al. [174]. These authors found that food insecure women lived in environmental settings with lower perceived safety, as compared to food secure women. Future research could focus on determining the link between neighborhood safety and physical activity in women participating in SNAP.

Nevertheless, this finding illustrates the positive influence of this aspect of the built environment on food insecurity, and body mass index in low-income women.

Finally, social eating, as defined by eating patterns while in the company of family and friends, also affected diet quality and BMI in this population. A limitation of this research is that the cross-sectional design could not capture changes over time. Also, the use of a FFQ to assess dietary intakes has been associated with lack of specificity and measurement error [17]. Furthermore, this investigation also could not take into account of the genetic determinants of body mass index. Finally, the sample recruited for this study was predominantly Hispanic, thereby limiting the generalizability of the findings to other ethnic groups.

CONCLUSIONS

These results are useful for public health interventions that aim to improve health behaviors in low-income women participating in SNAP. The relationship between food insecurity and obesity was partially elucidated by the MHES. The DGAI 2015 was helpful as a measure of diet quality and enabled identification of key food groups that were under- and over-consumed. Emphasis on resistance to emotional eating and favorable social eating behaviors could increase adherence to dietary recommendations, and thus improve diet quality. In addition, it may be beneficial for interventions to incorporate strategies to reduce the availability of unhealthy foods in the home environment. Finally, neighborhood safety also predicted BMI. Community-based

measures that help to overcome barriers of low neighborhood safety could facilitate women to achieve healthy weight status.

Chapter 6: Conclusions

The purpose of this research was to assess food purchasing patterns and monthly variations in nutrient and food group intake, and diet quality of SNAP participants. The first aim involved development and validation of a 95-item, 1-week food frequency questionnaire tailored to a population of women participating in SNAP. The second aim determined the adherence of food expenditure patterns of SNAP households to TFP recommendations. In the third aim, the validated food frequency questionnaire was utilized to assess the monthly variations in dietary intakes of SNAP-participating women. The intent of the fourth aim was to identify mediators of food insecurity and diet quality, and weight status of female SNAP participants with the help of a novel instrument, Multi-Dimensional Home Environmental Scale, that is based on the socio-ecological theory.

This research focused on women due to their vulnerability to consume diets that lack nutritional adequacy in an effort to provide for their families. Moreover, the existing body of literature has indicated that women participating in SNAP are more likely to be overweight and obese when compared to their income-eligible counterparts. A parallel association between SNAP participation and unhealthy weight status does not exist. In aim 1, a 95-item, 1-week food frequency questionnaire was developed and validated against 3-day diet records in female SNAP participants. Furthermore, test-retest reliability of the instrument was assessed by administration of the instrument for a second time with an interval of one month. The validity and reliability correlations of the

instrument were 0.61 and 0.66, thereby indicating acceptable psychometric properties to measure weekly diets of low-income women.

The purpose of aim 2 was to compare the food expenditure patterns of SNAP households via analysis of grocery receipts to TFP recommendations. The total monthly grocery expenditure, as well as the amounts spent on fruits, vegetables, low fat dairy and whole grains, were lower than the recommended TFP costs. Benefits from SNAP accounted for 79% of the total monthly grocery expenditure. An increase in the compliance of total grocery expenditure to the recommendation was associated with greater amounts spent on fruits, vegetables, low fat dairy and whole grains. On the other hand, amounts spent on refined grains, red meat, frozen entrees, sugar sweetened beverages, sugar, sweets and candies, and milk drinks and milk desserts exceeded the recommended allotments.

The 95-item food frequency questionnaire was used in Aim 3 to determine nutrient and food group intake, and diet quality of women in SNAP. A decrease in intakes of several nutrients was observed with time since receipt of benefits. The most important declines were observed for fiber, vitamin D, vitamin E, and calcium. Consumption of fruits, vegetables and dairy also decreased towards the end of month. Diet quality, as measured by Healthy Eating Index-2010 and Dietary Guidelines Adherence Index 2015, was lesser in week 4 than week 1 of the monthly distribution cycle. Furthermore, very low food secure women had poorer quality diets in weeks 3 and 4 when compared to food secure women.

In aim 4, emotional eating resistance, availability of unhealthy foods at home, neighborhood safety and social eating were significantly associated to body mass index of women in SNAP. Emotional eating resistance and social eating also were related to diet quality. Furthermore, the Multi-Dimensional Home Environmental Scale significantly mediated the relationship between food insecurity and weight status in this population.

This research is subject to a number of limitations. Food frequency questionnaires have been shown to lack specificity, and over-estimate the dietary intakes of a given population. However, the measurement bias may be correlated due to repeated administrations of the food frequency questionnaire over four weeks, thereby reducing the error associated with the desired outcome i.e. week-to-week variations in dietary intake. The samples used for all the aims are not representative of the SNAP population at a national level, due to its relatively small size and predominant Hispanic participation. In sum, this research significantly contributes to the existing literature by providing a detailed analysis of food expenditure patterns and dietary behaviors of SNAP participants. The lack of adherence of food expenditure patterns to recommendations implies that SNAP participants are likely to consume diets of poor quality. It is vital for nutrition interventions to focus on helping SNAP participants achieve a healthy diet within a budget. It also is important to address the decline in diet quality with an increase in time from receipt of benefits in this population. Resource management education, evaluation of adequacy of benefits and bi-monthly distribution of benefits are some policy measures that could overcome the decrease in diet quality. Finally, constructs of

the socio-ecological model significantly mediated the relationship between food insecurity and weight status of women participating in SNAP. Thus, obesity prevention interventions must comprehensively encompass several factors of the environment to achieve weight loss in this population of women.

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